O Level Pure Chemistry Structured

Metals Test 1.0

Q1

A metal verifier is an electronic device that can test for precious metals such as gold, silver and platinum. The verifier works by measuring the resistivity (how much each metal opposes the flow of current) of each metal, which is different for each metal and can therefore easily be distinguished.

The table below shows some information about the resistivity of some common materials. The lower the resistivity, the more readily electric current can flow through that metal.

metal	resistivity (Ωm) at 20 °C
carbon (diamond)	1.00×10^{12}
carbon (graphite)	
gold	2.44×10^{-8}
platinum	1.06×10^{-7}
silver	1.59×10^{-8}

(c) Precious metals sold commercially often have a purity of about 90-99.9%.

Explain why precious metals are sold commercially in the form of alloys instead of the pure metal.

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.....[2]

(d) In the table above, the resistivity values are measured at 20 °C.

Using kinetic particle theory, describe and explain how you would expect the resistivity of the materials to change if the temperature was raised to 40 °C.

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.....[2]

(e) Gold and silver can be extracted from old computers or electronic devices to be recycled and sold commercially.

Describe one advantage of recycling precious metals over mining.

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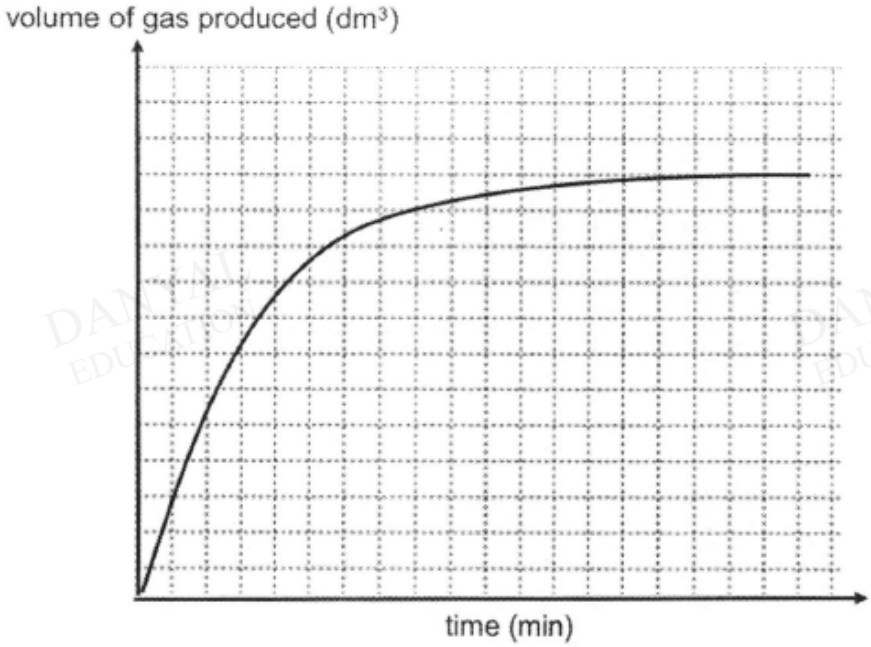
.....[1]

Q2

The reaction between 24 g of magnesium metal and 750 cm^3 of 2.00 mol/dm^3 sulfuric acid at room temperature and pressure can be monitored in the graph shown below.



(a) Write the chemical equation for the reaction. State symbols are not required.

.....[1]

(b) Calculate the maximum volume of gas obtained in this reaction at room temperature and pressure.

[3]

(c) **(i)** On the same axes, sketch the graph you would obtain if 24 g of zinc metal was used instead. [1]

(ii) Describe one variable you would keep constant to ensure that the experiment is fair.

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.....[1]

(d) When calcium metal is reacted instead, the initial production of gas is the fastest out of the three metals, but the reaction quickly stops.

Explain why this happens.

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.....[2]

(e) Describe another experiment you could carry out in the laboratory to deduce the order of reactivity of the three metals calcium, magnesium and zinc.

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.....[2]

[total = 10 marks]

Q3

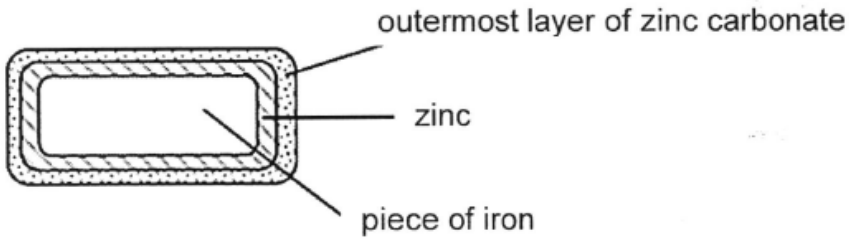
Galvanisation is the process of coating the entire surface of a piece of iron with zinc to prevent it from rusting. Two common ways of galvanising iron are hot-dip galvanisation and electro-galvanisation.

(a) Hot-dip galvanisation

The piece of iron to be galvanised is dipped into a molten bath of zinc at a temperature of around 460°C. The piece of iron is then cooled and exposed to the air. The outermost layer of zinc then reacts with oxygen and carbon dioxide in the air as follows:

reaction 1: zinc reacts with oxygen to form zinc oxide
reaction 2: zinc oxide reacts with carbon dioxide to form zinc carbonate

The resulting iron piece is as shown.



(i) Write balanced chemical equations for reaction 1 and reaction 2.

reaction 1 .....[1]

reaction 2 .....[1]

(ii) Use reaction 2 to explain how zinc oxide acts as a basic oxide.

.....[1]

(b) A student says 'galvanising a piece of iron is more effective in preventing it from rusting than painting it.'

Do you agree with the student? Explain your reasoning.

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.....[2]

Q4

B9 A student carried out some experiments to place four metals, **V**, **W**, **Y** and **Z** in order of reactivity.

Table 9.1 shows the results.

Key ✓ shows a reaction happened
× shows no reaction happened
– shows the experiment was not performed

Table 9.1

	metal **V**	metal **W**	metal **Y**	metal **Z**
solution of **V** nitrate	–	×	×	×
solution of **W** nitrate	✓	–	✓	✓
solution of **Y** nitrate	✓	×	–	✓
solution of **Z** nitrate	✓	×	×	–

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

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[2]

(b) Metal **Z** reacts with nitric acid.
What would you **see** when metal **Z** reacts with nitric acid?
Explain your reasoning.

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[2]

(c) The student carried out further experiments to place metal **N** in the list.
She used dilute nitric acid and samples of the metals.
She found out that metal **N** is the second most reactive metal.
Describe the experiments that the student carried out. Your answer should include

- the experiments that she carried out using dilute nitric acid and the samples of the metals,
- the measurements that she made,
- how the results showed that metal **N** is the second most reactive metal.

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[3]

(d) The five metals, **V**, **W**, **Y**, **Z** and **N** are extracted from their ores in three different ways.
Two of the metals are extracted from their ores by electrolysis.
Two of the metals are extracted by heating their ores with carbon.
One of the metals occurs uncombined.

(i) Suggest which metal occurs uncombined. Explain your answer.

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[2]

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

[1]

[10 marks]

Q5

A group of students were investigating the effects of 'acid rain'.
They decided to look at the effect of acid on metals used as building materials.
Lead and copper are used as materials for roofing and iron and aluminium can be used for window frames.

They learnt that the order of the reactivity of the metals as:

aluminium > iron > lead > copper

The students went on to test on the metals by adding dilute sulfuric acid to pieces of each metal to simulate the effects of 'acid rain' on the metals. It is found that only the iron seemed to give a reaction.

(a) Explain why the students deduce that aluminium did not react with the acid, even when aluminium is known to be more reactive than iron.

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..... [1]

(b) As the reaction was carried out with sulfuric acid, there were no reactions for both lead and copper. It did not prove that lead was more reactive than copper.

(i) Explain why the students cannot prove the reactivity of lead and copper using sulfuric acid.

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..... [2]

(ii) Briefly describe an experiment the students can carry out to show that lead is more reactive than copper. Explain how the above experiment can prove that lead is more reactive than copper.

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..... [3]

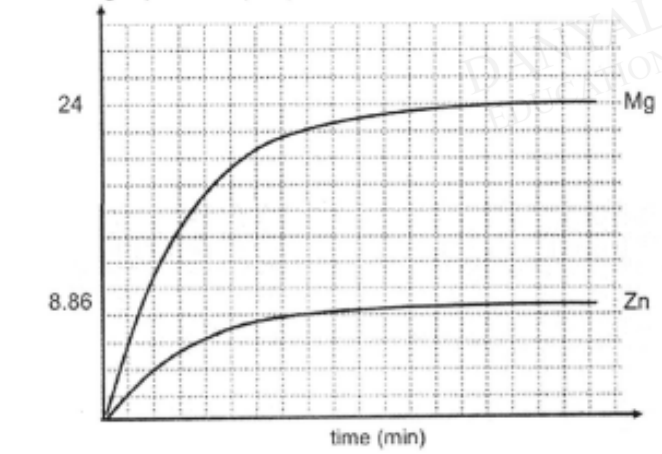
Answers

Metals Test 1.0

Q1

(c)	Pure metals are too soft to be sold commercially / alloys are harder. [1] In alloys, the different-sized atoms disrupt the regular arrangement / the layers of atoms do not slide over each other easily. [1]	[2]
(d)	When the temperature is increased, the electrons/particles (*atoms not accepted*) will move faster / have more kinetic energy so the material can conduct electricity better, [1] hence the resistivity should decrease. [1]	[2]
(e)	Recycling helps to conserve the finite resource of metals for future use / reduces land pollution from dumping or mining of metals / reduces air and water pollution during mining of metals	[1]

Q2

(a)	$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$	[1]
(b)	no. of moles of Mg = 24 g ÷ 24 = 1 mol [1] no. of moles of H_2SO_4 = 750/1000 · 2 = 1.5 mol [1] Mg is the limiting reagent. volume of H_2 = 1 · 24 = 24 dm^3 [1]	[3]
(c)(i)	 • Graph for Zn must have slower speed, and yield must be slightly more than 1/3 that of Mg • No need to label the volumes of gases on the vertical axes; if indicated, ecf for incorrect values • No need to label Mg and Zn	[1]
(c)(ii)	The particle size of each metal / concentration of the acid must be the same. *(Temperature not accepted because question already stated room temperature and pressure!)*	[1]
(d)	Calcium is the most reactive metal compared to magnesium and zinc, so it will react the fastest with sulfuric acid. [1] However, the reaction quickly stops because an insoluble layer of calcium sulfate forms around the metal, preventing further reaction. [1]	[2]
(e)	React the three metals separately with cold water. [1] Calcium is the most reactive so it will have the most vigorous effervescence, followed by magnesium with less effervescence. Zinc will not have any effervescence at all. **OR** Measure the volume of hydrogen gas produced within the same period of time. Calcium will produce the most gas first, followed by magnesium. Zinc will not produce any gas at all. [1]	[3]

Q3

EITHER B9a(i)	reaction 1: $2Zn + O_2 \rightarrow 2ZnO$ reaction 2: $ZnO + CO_2 \rightarrow ZnCO_3$	1 1
(ii)	It reacts with an <u>acidic oxide (carbon dioxide)</u> to form a salt (zinc carbonate).	1
b	Yes, galvanising protects the piece of iron from coming into contact with oxygen and water. If the protective layer is scratched, the exposed iron beneath will not rust as zinc is more reactive than iron and will corrode in place of iron. If the paint layer is scratched, the exposed iron beneath will start to rust when it reacts with oxygen and water.	1 1

Q4

(a) (most reactive) **V**, **Z**, **Y**, and **W** [2]

Award 1m for at least 2 metals in correct order.

(b) Effervescence / Bubbling of gas seen. [1]

Z will displace / produce hydrogen from the acid. [1]

(c) [New order: **V**, **N**, **Z**, **Y**, and **W**]

Add a <u>fixed mass</u> of each metal sample to a <u>fixed volume</u> of HNO_3 (aq). [1]

Measure the <u>volume of gas</u> collected over <u>regular time intervals</u> (i.e. reaction rate). [1]

Rate of reaction of **N** with the acid should be <u>slower</u> than **V** but <u>faster</u> than **Z**. [1]

(d) (i) **W** [1]

W is the least reactive of the 5 metals. Unreactive metals are usually found uncombined. [1]

(ii) zinc / iron [1]

[10 marks]

Q5

(a)		aluminium forms a **protective (insoluble) oxide layer** which react with the acid to form salt and water only. Hence no effervescence seen.	[1]
(b)	(i)	Lead reacts with sulfuric acid to form an **insoluble lead(II) sulfate coating** around lead. This forms a physical barrier **prevent further reaction** between the acid and lead.	[1]
		Copper is an **unreactive metal**. It does not react with acid to form salt and hydrogen gas.	[1]
	(ii)	Conducts a **metal displacement reaction** by **dipping a piece of lead metal and a piece of copper metal in separate solutions of copper(II) nitrate**.	[1]
		Lead metal in copper(II) nitrate: **blue copper (II) nitrate solution turns colourless/ reddish brown deposits**	[1]
		This shows that lead is a more reactive metal than copper and lead can **displace the less reactive metal (copper) from its solution**.	[1]
		[Total: 6 marks]	