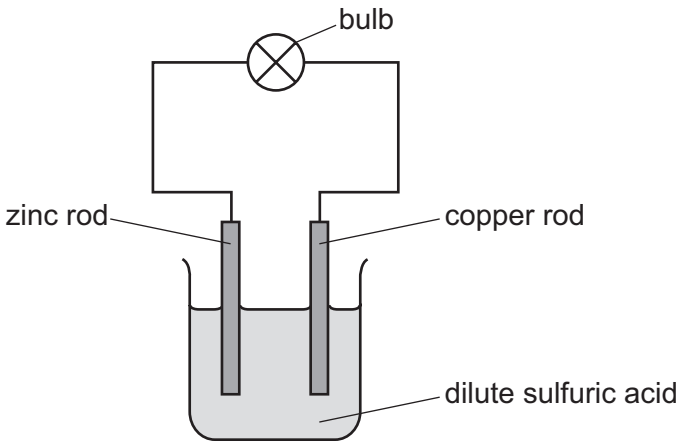
SIMPLE CELLS

1 **(a)** When rods of zinc and copper are placed into dilute sulfuric acid as shown, electricity is generated.



(i) Write the ionic half-equation for the reaction occurring at the zinc rod.

..... [2]

(ii) Write the ionic half-equation for the reaction occurring at the copper rod.

..... [2]

(iii) The copper rod was replaced by an iron rod.

Suggest the change, if any, in the intensity of the light emitted from the bulb and give a reason for your answer.

change .....

reason .....

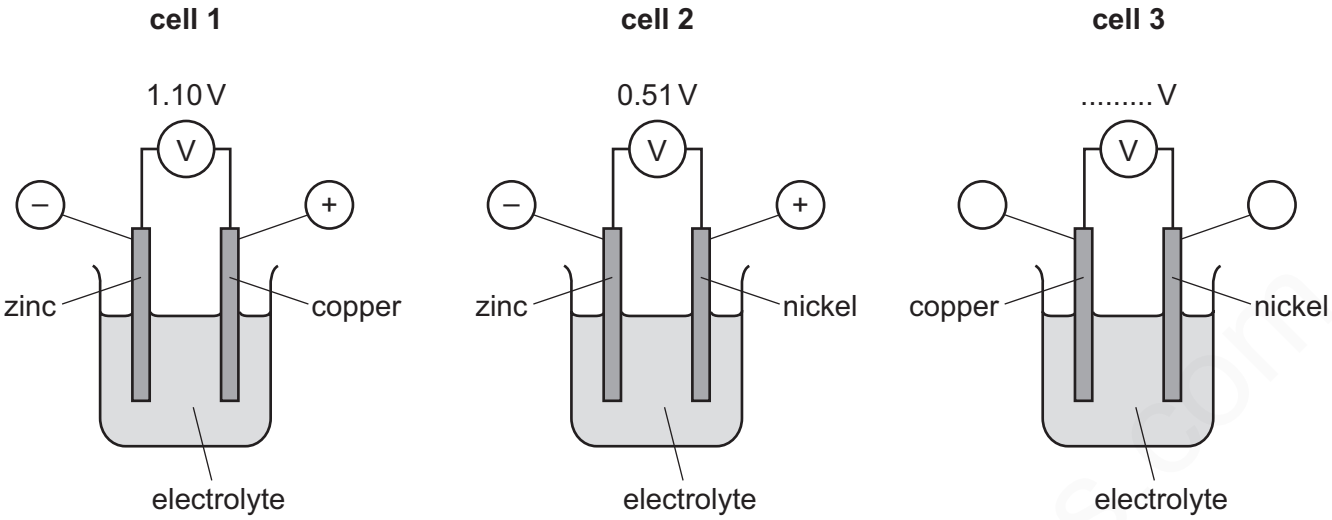
.....

[2]

MARKING SCHEME:

(i)	$Zn \rightarrow Zn^{2+} + 2e^-$ **M1** correct species **M2** correct balancing	**2**
(ii)	$2H^+ + 2e^- \rightarrow H_2$ **M1** correct species **M2** correct balancing	**2**
(iii)	change: (the intensity would) decrease	**1**
	reason: the difference in reactivity between zinc and iron is less than the difference in reactivity between zinc and copper	**1**

2 **(a)** Three cells are set up each using two metals.



(i) Write the ionic half-equation for the reaction occurring at the zinc electrode in **cell 1**.

..... [2]

(ii) Put the **three** metals, copper, nickel and zinc, in order of reactivity.

most reactive .....

↓ .....

least reactive .....

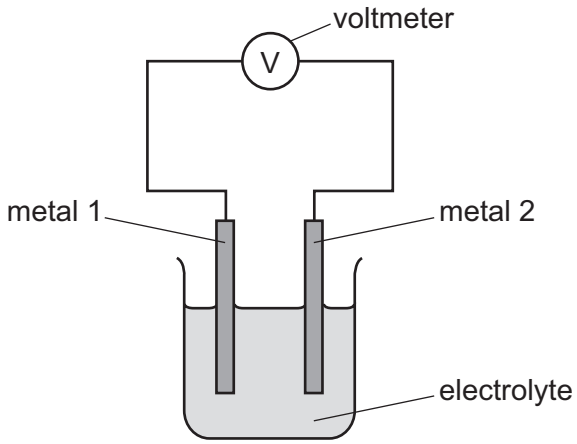
[1]

(iii) Complete the labelling in **cell 3** by writing the polarity (+/–) of each electrode in the circles and calculating the reading on the voltmeter. [2]

MARKING SCHEME:

(i)	$Zn \rightarrow Zn^{2+} + 2e / 2e^-$ **M1** formula of Zn^{2+} on the right-hand side **M2** equation fully correct	**2**
(ii)	zinc / Zn nickel / Ni copper / Cu	**1**
(iii)	copper (+) and nickel (–)	**1**
	0.59 V	**1**

3 The diagram shows a simple cell.



The simple cell was used with different metals as electrodes. The voltages were recorded in the table.

- If the voltage measured is positive then metal 2 is more reactive than metal 1.
- If the voltage measured is negative then metal 1 is more reactive than metal 2.

		metal 2				
		beryllium	cobalt	nickel	silver	vanadium
metal 1	beryllium	0.0 V	–1.6 V	–1.6 V	not measured	–0.7 V
	cobalt		0.0 V	0.0 V	–1.1 V	0.9 V
	nickel			0.0 V	–1.1 V	0.9 V
	silver				0.0 V	2.0 V
	vanadium					0.0 V

- The more reactive metal is oxidised.
- The bigger the difference in reactivity of the metals, the larger the reading on the voltmeter.

(a) In a simple cell using nickel and silver, the nickel is oxidised.

(i) Define *oxidation* in terms of electrons.

..... [1]

(ii) Nickel forms ions with a charge of +2.

Write an ionic half-equation to show the oxidation of nickel.

..... [1]

(iii) What will happen to the mass of the nickel electrode when the nickel is oxidised?

.....

..... [1]

(b) Use the data in the table to answer the following questions.

(i) Which of the metals in the table is the most reactive?
Explain your answer.

.....

..... [2]

(ii) State which **two** different metals have the same reactivity.

..... [1]

(iii) Predict the voltage produced by a simple cell with beryllium as metal 1 and silver as metal 2.

.....

..... [2]

(c) Describe how the simple cell in the diagram can be used to show that magnesium is more reactive than beryllium. Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

MARKING SCHEME:

(a)(i)	loss (of electrons)	**1**
(a)(ii)	$Ni \rightarrow Ni^{2+} + 2e^-$	**1**
(a)(iii)	goes down / gets less / decreases / lower / smaller	**1**
(b)(i)	beryllium	**1**
	most negative voltage with any (named) metal **OR** biggest voltage with cobalt / nickel	**1**
(b)(ii)	cobalt **AND** nickel	**1**
(b)(iii)	– sign	**1**
	2.7	**1**
(c)	(set up cell) using magnesium and beryllium (electrodes)	**1**
	voltage positive if magnesium is metal 2	**1**
	OR	
	(set up cells) using both magnesium and beryllium with the same metal as the other electrode	**1**
	larger (magnitude) voltages with magnesium	**1**
	OR	
	use magnesium with a different metal and compare to a reference value in a table	**1**
	value is more negative than with beryllium, if magnesium is metal 1	**1**

4 In the following list of ionic equations, the metals are in order of reactivity.

$\square \rightarrow \square + \square$

$Zn \rightarrow Zn^{2+} + 2e^-$

$Sn \rightarrow Sn^{2+} + 2e^-$ ↑ reactivity of metals increases

$Hg \rightarrow Hg^{2+} + 2e^-$

$Ag \rightarrow Ag^{+} + e^-$

(a) (i) In the space at the top of the series, write an ionic equation that includes a more reactive metal. [1]

(ii) Define *oxidation* in terms of electron transfer.

.....

[1]

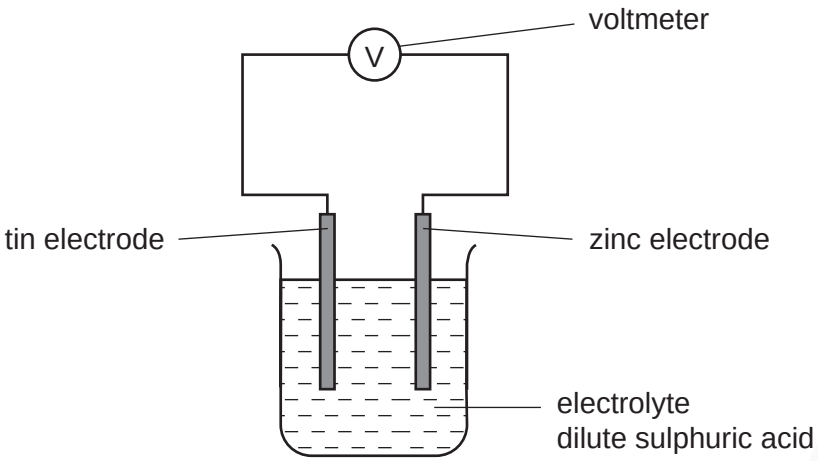
(iii) Explain why the positive ions are likely to be oxidising agents.

[1]

(iv) Which positive ion(s) can oxidise mercury metal (Hg)?

[1]

(b) The following diagram shows a simple cell.



(i) Predict how the voltage of the cell would change if the tin electrode was replaced with a silver one.

[1]

(ii) Which electrode would go into the solution as positive ions? Give a reason for your choice.

[1]

(iii) State how you can predict the direction of the electron flow in cells of this type.

[1]

MARKING SCHEME:

(a) (i) Correct equation with a more reactive metal **[1]**

(ii) Electron loss **[1]**

(iii) Because they can accept electrons or take electrons away from……. **[1]**

(iv) Silver or silver(I) **[1]**

(b) (i) increase **[1]**

(ii) zinc
COND and a correct reason - such as it loses electrons more easily **or** it is more reactive **[1]**
Need both zinc and reason for the mark.

(iii)from the more reactive to the less reactive **NOT** just from zinc to lead **[1]**

TOTAL = 7

5 One way of establishing a reactivity series is by displacement reactions.

(a) A series of experiments was carried out using the metals lead, magnesium, zinc and silver. Each metal was added in turn to aqueous solutions of the metal nitrates.

The order of reactivity was found to be:

magnesium	most reactive
zinc	↓
lead	
silver	least reactive

(i) Complete the table.

✓ = reacts
✗ = does not react

	metal			
aqueous solution	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead(II) nitrate		✓	✓	✗
magnesium nitrate				
zinc nitrate				
silver nitrate				

[3]

(ii) Displacement reactions are redox reactions.
On the following equation, draw a **ring** around the reducing agent and an **arrow** to show the change which is oxidation.

$$Zn + Pb^{2+} \rightarrow Zn^{2+} + Pb$$

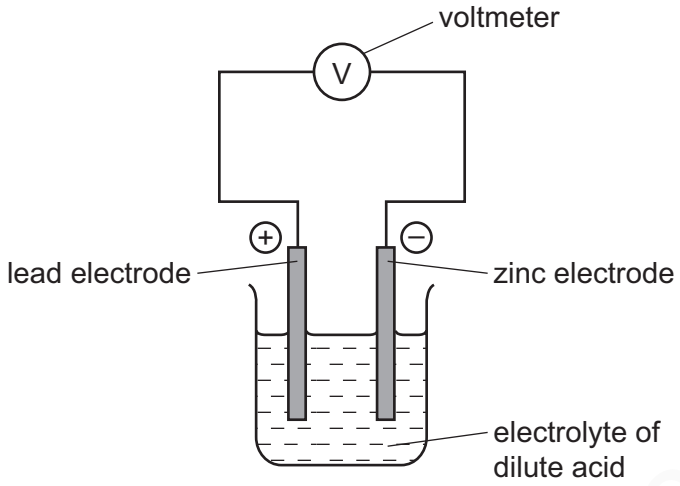
[2]

(iii) Complete the following ionic equation.

$$Zn + 2Ag^{+} \rightarrow \text{.....} + \text{.....}$$

[1]

(b) Another way of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells. The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode. An example of a simple cell is shown below.



(i) Mark on the above diagram the direction of the electron flow. [1]

(ii) Explain, in terms of electron transfer, why the more reactive metal is always the negative electrode.

.....

.....

..... [2]

(iii) The following table gives the polarity of cells using the metals zinc, lead, copper and manganese.

cell	electrode 1	polarity	electrode 2	polarity
A	zinc	–	lead	+
B	manganese	–	lead	+
C	copper	+	lead	–

What information about the order of reactivity of these four metals can be deduced from the table?

.....

.....

..... [2]

(iv) What additional information is needed to establish the order of reactivity of these four metals using cells?

..... [1]

[Total: 12]

MARKING SCHEME:

(a) (i)

aqueous solution	lead Pb	magnesium Mg	zinc Zn	silver Ag
lead (II) nitrate		✓	✓	×
magnesium nitrate	××		×	×
zinc nitrate	×	✓		×
silver(I) nitrate	✓	✓	✓	

each horizontal line correct (1) [3]

(ii) Zn (1)

An arrow **from** Zn **to** Zn^{2+} (1) [2]

(iii) $Zn + 2Ag^{+} \rightarrow Zn^{2+} + 2Ag$ (1) [1]

(b) (i) correct direction from zinc to lead (1) [1]

(ii) metals react by **losing electrons** (1)

the more reactive metal / zinc will lose electrons more readily (making the electrode negatively charged). (1) [2]

(iii) manganese **and** zinc are more reactive than lead (and / or copper) (1)

lead is more reactive than copper (1) [2]

(iv) the **polarity** of a Mn / Zn (cell)
or the **voltages** of Zn / Pb **and** Mn / Pb (cells) (1) [1]

[Total: 12]