1 Vanadium is a transition element.

(a) An atom of the most common isotope of vanadium can be represented as $^{51}_{23}V$.

Complete the following table to show the number of protons, electrons and neutrons in each particle.

particle	number of protons	number of electrons	number of neutrons
$^{51}_{23}V$			
$^{51}_{23}V^{3+}$			
$^{50}_{23}V$			

[3]

(b) The major use of vanadium is to make vanadium steel alloys.

(i) Explain the phrase *steel alloys*.

.....

..... [2]

(ii) State the name and use of another steel alloy.

name .....

use ..... [2]

(c) Two of the oxidation states of vanadium are +3 and +4.

(i) Write the formula of vanadium(III) oxide and of vanadium(IV) oxide.

vanadium(III) oxide .....

vanadium(IV) oxide ..... [2]

(ii) Vanadium(III) oxide is basic and vandium(IV) oxide is amphoteric.
Describe how you would obtain a sample of vanadium(III) oxide from a mixture of these two oxides.

.....

.....

..... [3]

[Total: 12]

2 The reactions of a metal and the thermal stability of some of its compounds are determined by the position of the metal in the reactivity series.

(a) To find the order of reactivity of the metals, cobalt, magnesium, silver and tin, the following experiments were carried out.

experiment	result
tin plus silver(I) nitrate solution	silvery layer on tin
magnesium plus tin(II) nitrate solution	grey deposit on magnesium
tin plus cobalt nitrate solution	no reaction

(i) Give as far as possible the order of reactivity of these metals.
Write the least reactive first.

..... [2]

(ii) What additional experiment needs to be done to put all four metals in order of reactivity?

..... [1]

(iii) Write an ionic equation for the reaction between tin atoms and silver(I) ions. Indicate on the equation the change which is oxidation.

.....

..... [3]

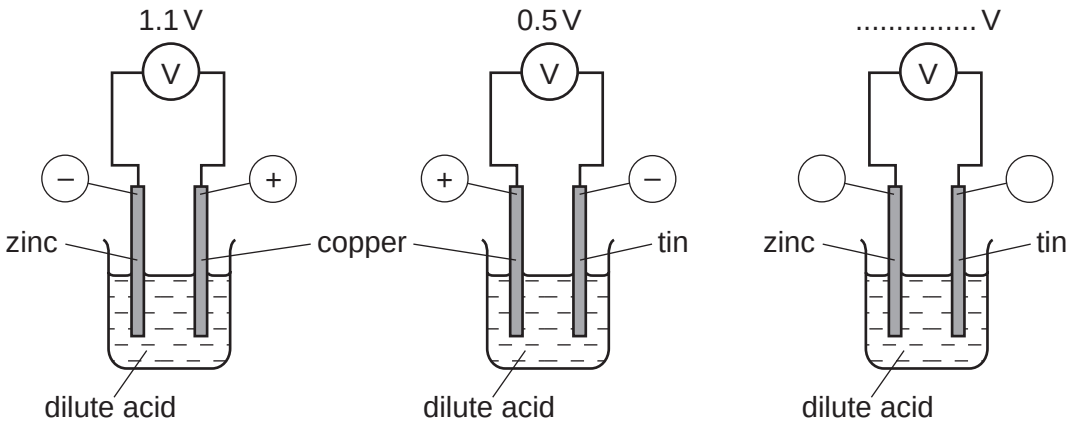
(b) Sodium is a more reactive metal than magnesium. Sodium compounds are more stable than magnesium compounds.

In an experiment, their hydroxides were heated. If the hydroxide did not decompose write 'no reaction' otherwise complete the equation.

$NaOH \rightarrow$ .....

$Mg(OH)_2 \rightarrow$ ..... [2]

(c) A cell consists of two different metal electrodes in an electrolyte.
Three possible cells are shown below.



(i) Why is the more reactive metal the negative electrode?

.....

..... [2]

(ii) How can you deduce that zinc is more reactive than tin?

..... [1]

(iii) How could you change the zinc/copper cell to have a voltage greater than 1.1 V?

..... [1]

(iv) Complete the labelling of the zinc/tin cell. [2]

[Total: 14]

3 The reactivity series of metals given below contains both familiar and unfamiliar elements. For most of the unfamiliar elements, which are marked *, their common oxidation states are given.

* bariu	Ba
* lanthanu	La (+3)
magnesium	
zinc	
* chromiu	Cr (+2), (+3), (+6)
iron	
copper	
* palladiu	(+2)

Choose metal(s) from the above list to answer the following questions.

(i) Which **two** metals would not react with dilute hydrochloric acid?

.....

[2]

(ii) Which **two** unfamiliar metals (*) would react with cold water?

.....

[2]

(iii) What is the oxidation state of barium?

.....

[1]

(iv) Name an unfamiliar metal (*) whose oxide cannot be reduced by carbon.

.....

[1]

(v) Why should you be able to predict that metals such as iron and chromium have more than one oxidation state?

.....

.....

[1]

[Total: 7]

4 **(a** An important ore of zinc is zinc blende, ZnS.

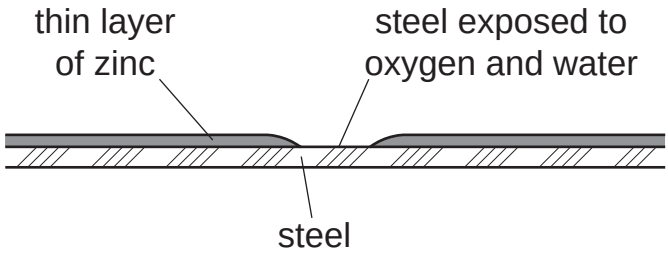
(i) How is zinc blende changed into zinc oxide?

..... [1]

(ii) Write a balanced equation for the reduction of zinc oxide to zinc by carbon.

..... [2]

(b) 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.

.....

.....

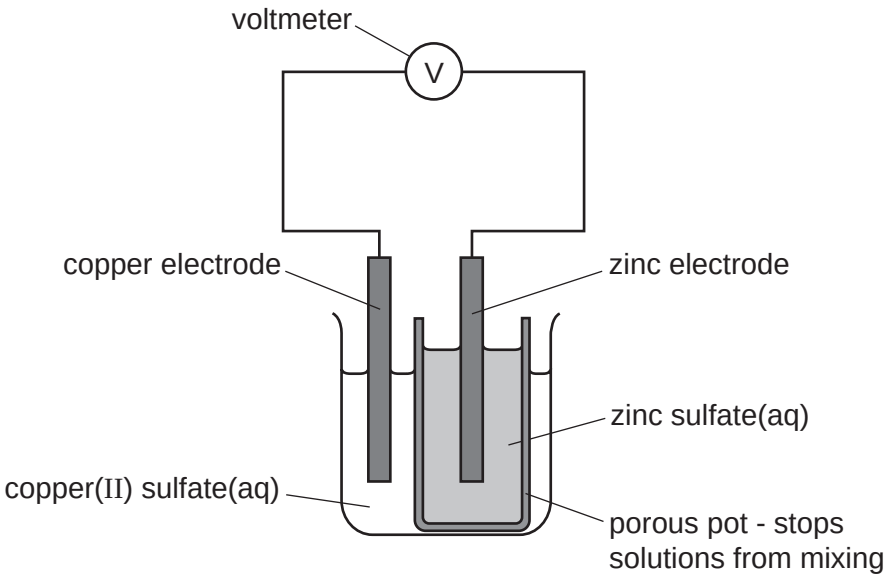
.....

.....

.....

..... [3]

(c) Zinc electrodes have been used in cells for many years, one of the first was the Daniel cell in 1831.



(i) Give an explanation for the following in terms of atoms and ions.

observation at zinc electrode – *the electrode becomes smaller*

explanation .....

..... [1]

observation at copper electrode – *the electrode becomes bigger*

explanation .....

..... [1]

(ii) When a current flows, charged particles move around the circuit.

What type of particle moves through the electrolytes?

..... [1]

Which particle moves through the wires and the voltmeter?

..... [1]

[Total: 10]

5 Copper is purified by electrolysis.

(a) Complete the following.

The positive electrode (anode) is made from .....

The negative electrode (cathode) is made from .....

The electrolyte is aqueous ..... [3]

(b) Write an ionic equation for the reaction at the positive electrode (anode).

..... [2]

(c) Give **two** reasons why copper is used,

in electric wiring, ...

..... [2]

in cooking utensils. .....

..... [2]

(ii) Give another use of copper.

..... [1]

[Total: 10]

6 Steel is an alloy made from impure iron.

(a) Both iron and steel rust. The formula for rust is $Fe_2O_3.2H_2O$.
It is hydrated iron(III) oxide.

(i) Name the **two** substances that must be present for rusting to occur.

.....

[2]

(ii) Painting and coating with grease are two methods of preventing iron or steel from rusting. Give **two** other methods.

.....

.....

[2]

(b) Name a reagent that can reduce iron(III) oxide to iron.

.....

[1]

(ii) Write a symbol equation for the reduction of iron(III) oxide, Fe_2O_3, to iron.

.....

[2]

(c) Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

.....

[1]

(ii) Use your answer to **(i)** to calculate the percentage of iron in rust.

.....

.....

[2]

(d) Iron from the blast furnace is impure. Two of the impurities are carbon and silicon. These are removed by blowing oxygen through the molten iron and adding calcium oxide.

(i) Explain how the addition of oxygen removes carbon.

.....

.....

[1]

(ii) Explain how the addition of oxygen and calcium oxide removes silicon.

.....

.....

[2]

[Total: 13]