1 Crystals of copper(II) nitrate, $Cu(NO_3)_2$, can be prepared by reacting solid copper(II) oxide, CuO, with dilute nitric acid.

(a) Write a chemical equation for this reaction.

(1)

.....

(b) A student is given a sample of copper(II) oxide containing small amounts of insoluble impurities.

The passage is from her notebook and describes the method she uses to prepare some pure, dry crystals of copper(II) nitrate from her sample of copper(II) oxide.

Stage 1: Place 50 cm^3 of dilute nitric acid into a beaker and warm.

Stage 2: Add the impure copper(II) oxide a little at a time and stir, until it is in excess.

Stage 3: Filter the mixture.

Stage 4: Heat the filtrate until the crystallisation point is reached.

Stage 5: Allow the filtrate to cool.

Stage 6: Filter off the crystals and dry with filter paper.

(i) Why is the acid warmed in stage 1?

(1)

.....

.....

(ii) How will the student know when the copper(II) oxide is in excess in stage 2?

(1)

.....

.....

(iii) How will the student know when the crystallisation point is reached in stage 4?

(1)

.....

.....

(iv) In which stage are the insoluble impurities removed?

(1)

.....

(Total for Question 1 = 5 marks)

2 Iron is a metal with many uses. One problem with using iron is that it rusts.

(a) Name two substances needed for iron to rust.

(2)

..... and .....

(b) State the name of the main compound present in rust.

(1)

.....

(c) The table shows three methods used to protect iron from rusting.

Choose three of the objects from the box to complete the table.
You may choose an object only once.

(3)

bicycle chain	bucket	car body
car engine	food can	railway bridge

Method	Example of use
galvanising	
oiling	
painting	

(d) An iron object is coated with zinc to protect it from rusting. This protection continues even if the zinc coating becomes scratched.

Explain how the zinc coating protects iron from rusting.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 2 = 8 marks)

3 Nickel is an important metal.

(a) Three of the stages in the extraction of nickel from its ore are

stage 1 nickel(II) oxide is reduced by heating with H_2 to produce impure nickel

$$NiO(s) + H_2(g) \rightarrow Ni(s) + H_2O(g)$$

stage 2 the impure nickel is reacted with CO

$$Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$$

stage 3 $Ni(CO)_4$ is decomposed by heating to produce pure nickel

$$Ni(CO)_4(g) \rightarrow Ni(s) + 4CO(g)$$

(i) State why the reaction in stage 1 is described as reduction.

(1)

.....

.....

(ii) Suggest why a low temperature produces a high yield of $Ni(CO)_4$ in stage 2.

(2)

.....

.....

.....

(b) Nickel has a melting point of 1455 °C and is a good conductor of electricity.

(i) Draw a labelled diagram to show the arrangement of the particles in nickel.

(3)

(ii) Explain, in terms of its structure, why nickel is malleable and is a good conductor of electricity.

(4)

(Total for Question 3 = 10 marks)

4 Iron and aluminium are two important metals extracted from their ores on a large scale.

(a) In the extraction of iron, three different raw materials are put into the top of a blast furnace.

Name the main compound present in the following raw materials.

(i) Haematite

(1)

.....

(ii) Limestone

(1)

.....

(b) The following equations represent reactions in the blast furnace.

A $C + O_2 \rightarrow CO_2$

B $CaCO_3 \rightarrow CaO + CO_2$

C $C + CO_2 \rightarrow 2CO$

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

E $CaO + SiO_2 \rightarrow CaSiO_3$

Choose from the letters **A**, **B**, **C**, **D** or **E** to answer parts (i) – (iv).

Each letter may be used once, more than once or not at all.

(4)

(i) A reaction that is used to produce heat .....

(ii) A neutralisation reaction .....

(iii) A decomposition reaction .....

(iv) A reaction that forms a reducing agent .....

(c) Molten iron and another molten substance collect at the bottom of the blast furnace.

What is the common name of this other molten substance?

(1)

.....

(d) Aluminium is extracted from its ore by electrolysis. This is a more expensive process than using a blast furnace.

(i) Why is a different method used for aluminium?

(1)

.....

.....

(ii) State the major reason for the high cost of extracting aluminium.

(1)

.....

.....

(e) Coke used in the blast furnace contains carbon. Carbon is also used in the extraction of aluminium, but for a different purpose.

What is this purpose?

(1)

.....

.....

(f) The extraction of aluminium can be represented by the chemical equation:

$$2Al_2O_3 \rightarrow 4Al + 3O_2$$

Write the two ionic half-equations that can also be used to represent this extraction.

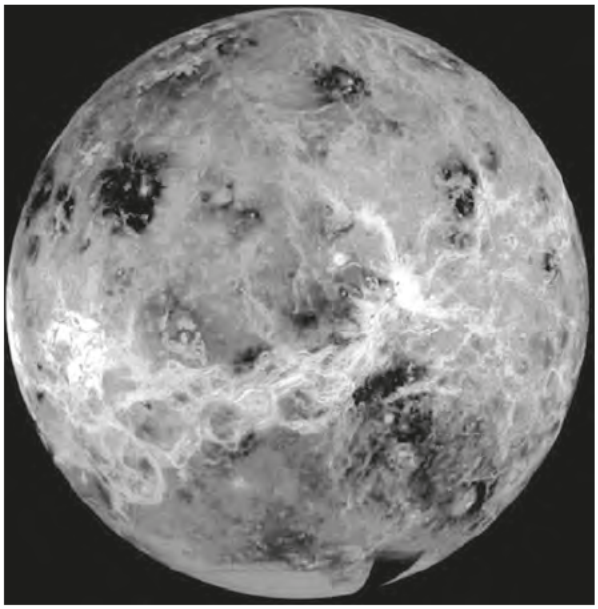
(3)

Half-equation 1 .....

Half-equation 2 .....

(Total for Question 4 = 13 marks)

5 The photograph shows the planet Venus.



Although Venus is similar in size to the Earth, it is very different in other ways.

The temperature at the surface of Venus is about 470 °C. The atmospheric pressure is 90 times that of the Earth.

The clouds in the atmosphere of Venus are made up of droplets of sulfuric acid.

The table lists some properties of metals that could be used to make a space probe to land on Venus.

Metal	Melting point in °C	Relative density	Reaction with sulfuric acid
copper	1083	8.9	no reaction
lead	328	11.3	no reaction
magnesium	650	1.7	fizzes vigorously
nickel	1453	8.9	fizzes slowly
titanium	1675	4.5	no reaction
zinc	420	7.1	fizzes quite vigorously

The probe needs to be launched with enough energy to escape the Earth's gravity. To make this easier, the mass of the probe needs to be as low as possible. The probe also needs to withstand the conditions on the surface of Venus.

Use the information in the table to answer parts (a) to (c).

(a) (i) Which metal in the table could be used to make a probe with the lowest density?

(1)

(ii) Why would this metal be unsuitable for making a probe to land on Venus?

(1)

(b) Very small amounts of lead can be used in electrical circuits.

Why would lead **not** be suitable for use in the electrical circuits of a probe to land on Venus?

(1)

(c) Choose a metal from the table that would be the **most** suitable for making a probe to land on Venus. Give **two** reasons for your choice.

(3)

Metal

Reasons

1

2

(Total for Question 5 = 6 marks)

6 Tungsten is a useful metal. It has the chemical symbol W.

(a) One method of extracting tungsten involves heating a tungsten compound (WO_3) with hydrogen.

(i) Suggest the chemical name of WO_3

(1)

.....

(ii) Balance the equation for the reaction between WO_3 and hydrogen.

(1)

WO_3 + ...H_2 → .....W + ...H_2O

(iii) Why is this reaction described as reduction?

(1)

.....

.....

(b) Scheelite is an ore of tungsten.

The main compound in scheelite has the percentage composition by mass Ca = 13.9%, W = 63.9%, O = 22.2%.

Calculate the empirical formula of this compound.

(3)

empirical formula = ...

(c) Tungsten can also be obtained by reacting tungsten fluoride with hydrogen.

The equation for this reaction is

$$WF_6 + 3H_2 \rightarrow W + 6HF$$

(i) In an experiment, a chemist used 59.6 g of tungsten fluoride.

What is the maximum mass of tungsten he could obtain from 59.6 g of tungsten fluoride?

Relative formula mass of tungsten fluoride = 298

(2)

maximum mass = ... g

(ii) Starting with a different mass of tungsten fluoride, he calculates that the mass of tungsten formed should be 52.0 g. In his experiment he actually obtains 47.5 g of tungsten.

What is the percentage yield of tungsten in this experiment?

(2)

percentage yield = ... %

(Total for Question 6 = 10 marks)