1 **(a)** Different gases diffuse at different speeds.

(i) What is meant by the term *diffusion*?

.....

..... [1]

(ii) What property of a gas molecule affects the speed at which it diffuses?

..... [1]

(b) Helium is a gas used to fill balloons. It is present in the air in very small quantities. Diffusion can be used to separate it from the air.

Air at 1000 °C is on one side of a porous barrier. The air which passes through the barrier has a larger amount of helium in it.

(i) Why does the air on the other side of the barrier contain more helium?

..... [1]

(ii) Why is it an advantage to have the air at a high temperature?

.....

..... [1]

(c) Most helium is obtained from natural gas found in the USA. Natural gas contains methane and 7% helium. One possible way to obtain the helium would be to burn the methane.

(i) Write an equation for the complete combustion of methane.

..... [1]

(ii) Suggest why this would **not** be a suitable method to obtain the helium.

.....

..... [1]

(iii) Suggest another method, other than diffusion, by which helium could be separated from the mixture of gases in natural gas.

..... [1]

[Total: 7]

2 For centuries, iron has been extracted from its ore in the blast furnace. The world production of pig iron is measured in hundreds of million tonnes annually.

(a) The following raw materials are supplied to a modern blast furnace.

iron ore which is hematite, Fe_2O_3
limestone which is calcium carbonate
carbon in the form of coke
air

Describe the essential reactions in the blast furnace. Each of the four raw materials must be mentioned at least once. Give the equation for the reduction of hematite.

.....

.....

.....

.....

.....

.....

.....

.....

..... [6]

(b) Each year, blast furnaces discharge millions of tonnes of carbon dioxide into the atmosphere. This will increase the percentage of atmospheric carbon dioxide.

(i) Explain why this increased percentage of carbon dioxide may cause problems in the future.

.....

..... [2]

(ii) Until the early eighteenth century, charcoal, not coke, was used in the blast furnace. Charcoal is made from wood but coke is made from coal. Explain why the use of charcoal would have a smaller effect on the level of atmospheric carbon dioxide.

.....

.....

..... [2]

(iii) A method being developed to produce iron with lower emissions of carbon dioxide is by electrolysis. Hematite, Fe_2O_3, is dissolved in molten lithium carbonate and electrolysed. The ore is spilt into its constituent elements.

Write an equation for the reaction at the negative electrode (cathode).

.....

Complete the equation for the reaction at the positive electrode (anode).

.....O^{2-} $\rightarrow$ ..... + ... [3]

[Total: 13]

3 The following reactivity series shows both familiar and unfamiliar elements in order of decreasing reactivity. Each element is represented by a redox equation.

$$Rb \rightleftharpoons Rb^{+} + e^{-}$$
$$Mg \rightleftharpoons Mg^{2+} + 2e^{-}$$
$$Mn \rightleftharpoons Mn^{2+} + 2e^{-}$$
$$Zn \rightleftharpoons Zn^{2+} + 2e^{-}$$
$$H_2 \rightleftharpoons 2H^{+} + 2e^{-}$$
$$Cu \rightleftharpoons Cu^{2+} + 2e^{-}$$
$$Hg \rightleftharpoons Hg^{2+} + 2e^{-}$$

Two of the uses of the series are to predict the thermal stability of compounds of the metals and to explain their redox reactions.

(a) Most metal hydroxides decompose when heated.

(i) Complete the equation for the thermal decomposition of copper(II) hydroxide.

$Cu(OH)_2 \rightarrow$ ..... + ... [1]

(ii) Choose a metal from the above series whose hydroxide does not decompose when heated.

..... [1]

(b) Define in terms of electron transfer the term *oxidation*.

..... [1]

(ii) Explain why the positive ions in the above equations are oxidising agents.

.....

..... [1]

(c) Which metals in the series above do not react with dilute acids to form hydrogen?

..... [1]

(ii) Describe an experiment which would confirm the prediction made in **(c)(i)**.

.....

..... [1]

(d) Which metal in the series above can form a negative ion which gives a pink / purple solution in water?

..... [1]

(ii) Describe what you would observe when zinc, a reducing agent, is added to this pink / purple solution.

..... [1]

[Total: 8]

4 This question is concerned with the elements in Period 5, Rb to Xe.

(a) The electron distributions of some of these elements are given in the following list.

element **A** 2 +
element **B** 2 +
element **C** 2 +
element **D** 2 +
element **E** 2 + 8 + 18 + 18 + 4
element **F** 2 + 8 + 18 + 18 + 7

(i) Identify element **C**. ..... [1]

(ii) Which element in the list does not form any compounds?

..... [1]

(iii) Which element in the list forms a chloride of the type XCl_2?

..... [1]

(iv) Which **two** elements would react together to form a compound of the type XY_4?

..... [1]

(v) Which element in the list would react with cold water to form an alkaline solution and hydrogen?

..... [1]

(b) Predict **two** differences in physical properties and **two** differences in chemical properties between rubidium and the transition metal niobium.

physical .....

.....

.....

chemical .....

.....

..... [4]

[Total: 9]

5 Strontium and sulphur chlorides both have a formula of the type XCl_2 but they have different properties.

property	strontium chloride	sulphur chloride
appearance	white crystalline solid	red liquid
melting point / °C	87	-8
particles present	ions	molecules
electrical conductivity of solid	poor	poor
electrical conductivity of liquid	good	poor

(a) The formulae of the chlorides are similar because both elements have a valency of 2. Explain why Group II and Group VI elements both have a valency of 2.

.....

[2]

(b) Draw a diagram showing the arrangement of the valency electrons in one covalent molecule of sulphur chloride.
Use x to represent an electron from a sulphur atom.
Use o to represent an electron from a chlorine atom.

[3]

(c) Explain the difference in electrical conductivity between the following.

(i) solid and liquid strontium chloride

[1]

(ii) liquid strontium chloride and liquid sulphur chloride

[1]

6 The elements in Period 3 and some of their common oxidation states are shown below.

Element	Na	Mg	Al	Si	P	S	Cl	Ar
Oxidation State	+1	+2	+3	+4	–3	–2	–1	0

(a) **(i)** Why do the oxidation states increase from sodium to silicon?

.....[1]

(ii) After Group(IV) the oxidation states are negative and decrease across the period. Explain why.

.....

.....[2]

(b) The following compounds contain two elements. Predict their formulae.

aluminium sulphide .....

silicon phosphide ..... [2]

(c) Choose a different element from Period 3 that matches each description.

(i) It has a similar structure to diamond.

.....[1]

(ii) It reacts violently with cold water to form a solution pH = 14.

.....[1]

(iii) It has a gaseous oxide of the type XO_2, which is acidic.

.....[1]

(d) The only oxidation state of argon is zero. Why it is used to fill light bulbs?

.....

.....[1]

(e) Draw a diagram that shows the arrangement of the valency electrons in the ionic compound sodium phosphide.

Use o to represent an electron from sodium.
Use x to represent an electron from phosphorus. [3]

(f) Sodium reacts with sulphur to form sodium sulphide.

$$2Na + S \rightarrow Na_2S$$

An 11.5 g sample of sodium is reacted with 10 g of sulphur. All of the sodium reacted but there was an excess of sulphur.
Calculate the mass of sulphur left unreacted.

(i) Number of moles of sodium atoms reacted = ...
[2 moles of Na react with 1 mole of S]

(ii) Number of moles of sulphur atoms that reacted = ...

(iii) Mass of sulphur reacted = ...g

(iv) Mass of sulphur left unreacted = ...g [4]