1 Calcium reacts with nitrogen to form the ionic compound calcium nitride, Ca_3N_2.

(a) Draw a diagram, based on the correct formula, which shows the charges on the ions and the arrangement of the electrons around the negative ion.

Use o to represent an electron from a calcium atom.
Use x to represent an electron from a nitrogen atom.

[3]

(b) In the lattice of calcium nitride, the ratio of calcium ions to nitride ions is 3 : 2.

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

.....

..... [2]

(ii) In terms of ionic charges, explain why the ratio of ions is 3 : 2.

.....

..... [2]

(c) The reaction between calcium and nitrogen to form calcium nitride is a redox reaction.

In terms of electron transfer, explain why calcium is the reducing agent.

.....

.....

.....

..... [3]

[Total: 10]

2 Ammonia is manufactured by the Haber process. Nitrogen and hydrogen are passed over a catalyst at a temperature of 450 °C and a pressure of 200 atmospheres.

The equation for the reaction is as follows.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

The forward reaction is exothermic.

(a) State **one** use of ammonia.

..... [1]

(b) What is the meaning of the symbol $\rightleftharpoons$?

..... [1]

(c) What are the sources of nitrogen and hydrogen used in the Haber process?

nitrogen .....

hydrogen .....
[2]

(d) Name the catalyst in the Haber process.

..... [1]

(e) If a temperature higher than 450 °C was used in the Haber process, what would happen to the **rate** of the reaction? Give a reason for your answer.

.....

.....

..... [2]

(ii) If a temperature higher than 450 °C was used in the Haber process, what would happen to the **yield** of ammonia? Give a reason for your answer.

.....

.....

..... [2]

(f) If a pressure higher than 200 atmospheres was used in the Haber process, what would happen to the **yield** of ammonia? Give a reason for your answer.

.....

.....

..... [2]

(ii) Explain why the rate of reaction would be faster if the pressure was greater than 200 atmospheres.

.....

..... [1]

(iii) Suggest **one** reason why a pressure higher than 200 atmospheres is not used in the Haber process.

.....

..... [1]

(g) Draw a dot-and-cross diagram to show the arrangement of the outer (valency) electrons in one molecule of ammonia.

[2]

(h) Ammonia acts as a base when it reacts with sulfuric acid.

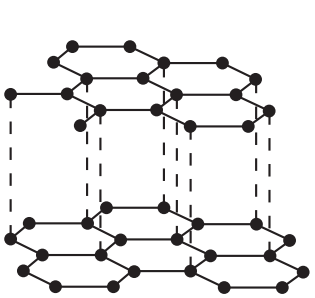
(i) What is a base?

..... [1]

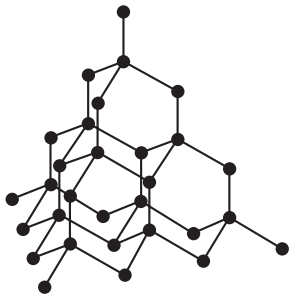
(ii) Write a balanced equation for the reaction between ammonia and sulfuric acid.

..... [2]

3 Two macromolecular forms of carbon are graphite and diamond. The structures of graphite and diamond are given below.



graphite



diamond

(a) Explain in terms of its structure why graphite is soft and is a good conductor of electricity.

.....

.....

.....

.....

..... [3]

(b) State **two** uses of graphite which depend on the above properties.

It is soft .....

.....

It is a good conductor of electricity .....

.....

[2]

(c) Silicon(IV) oxide also has a macromolecular structure.

(i) Describe the macromolecular structure of silicon(IV) oxide.

.....

..... [1]

(ii) Predict **two** physical properties which diamond and silicon(IV) oxide have in common.

.....

..... [2]

4 For each of the following elements give **one** physical property and **one** chemical property.

(a) bromine (Br_2)

physical property .....

chemical property .....

[2]

(b) carbon$_{graphite}$(C)

physical property .....

chemical property .....

[2]

(c) manganese (Mn)

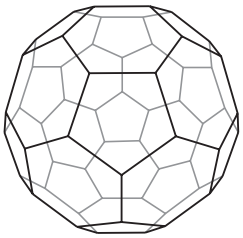
physical property .....

chemical property .....

[2]

[Total: 6]

5 In 1985 the fullerenes were discovered. They are solid forms of the element carbon. The structure of the C_{60} fullerene is given below.



(a) (i) In the C_{60} fullerene, how many other carbon atoms is each carbon atom bonded to?

..... [1]

(ii) Another fullerene has a relative molecular mass of 840.
How many carbon atoms are there in one molecule of this fullerene?

..... [1]

(b) Fullerenes are soluble in liquid hydrocarbons such as octane. The other solid forms of carbon are insoluble.
Describe how you could obtain crystals of fullerenes from soot which is a mixture of fullerenes and other solid forms of carbon.

.....

.....

.....

..... [3]

(c) A mixture of a fullerene and potassium is an excellent conductor of electricity.

(i) Which other form of solid carbon is a good conductor of electricity?

..... [1]

(ii) Explain why metals, such as potassium, are good conductors of electricity.

.....

..... [2]

(iii) The mixture of fullerene and potassium has to be stored out of contact with air. There are substances in unpolluted air which will react with potassium.
Name **two** potassium compounds which could be formed when potassium is exposed to air.

..... [2]

[Total: 10]

6 The table below gives the electron distributions of atoms of different elements.

element	electron distribution
A	2 + 7
B	2 + 8 + 4
C	2 + 8 + 8 + 1
D	2 + 8 + 18 + 5
E	2 + 8 + 18 + 7
F	2 + 8 + 18 + 18 + 8

For each of the following, select an element or elements from the table that matches the description. Each element may be selected once, more than once or not at all.

(a) These **two** elements are in the same group.

..... [1]

(b) This element forms a fluoride with a formula of the type XF_3.

..... [1]

(c) This element reacts violently with cold water.

..... [1]

(d) This element has a macromolecular structure similar to that of diamond.

..... [1]

(e) The only oxidation state of this element is 0.

..... [1]

(f) This element is bromine.

..... [1]

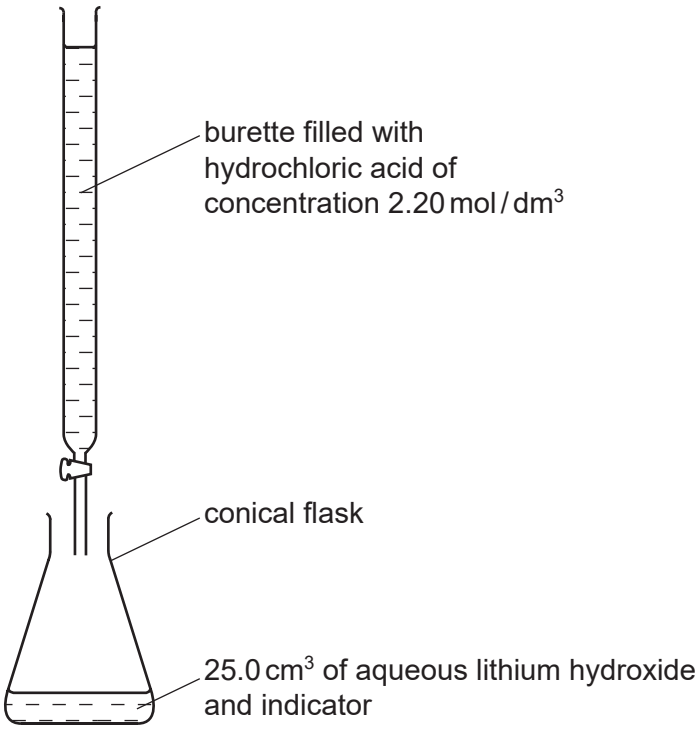
(g) This element is a good conductor of electricity.

..... [1]

[Total: 7]

7 The hydroxides of the Group I metals are soluble in water. Most other metal hydroxides are insoluble in water.

(a) (i) Crystals of lithium chloride can be prepared from lithium hydroxide by titration.



25.0 cm^3 of aqueous lithium hydroxide is pipetted into the conical flask.
A few drops of an indicator are added. Dilute hydrochloric acid is added slowly to the alkali until the indicator just changes colour. The volume of acid needed to neutralise the lithium hydroxide is noted.

A neutral solution of lithium chloride, which still contains the indicator, is left. Describe how you could obtain a neutral solution of lithium chloride which does **not** contain an indicator.

.....

..... [2]

(ii) You cannot prepare a neutral solution of magnesium chloride by the same method. Describe how you could prepare a neutral solution of magnesium chloride.

.....

.....

..... [3]

(b) The concentration of the hydrochloric acid was 2.20 mol / dm^3. The volume of acid needed to neutralise the 25.0 cm^3 of lithium hydroxide was 20.0 cm^3. Calculate the concentration of the aqueous lithium hydroxide.

$$LiOH + HCl \rightarrow LiCl + H_2O$$

.....

.....

..... [2]

(c) Lithium chloride forms three hydrates. They are $LiCl.H_2O$, $LiCl.2H_2O$ and $LiCl.3H_2O$. Which **one** of these three hydrates contains 45.9 % of water?
Show how you arrived at your answer.

.....

.....

..... [3]

[Total: 10]