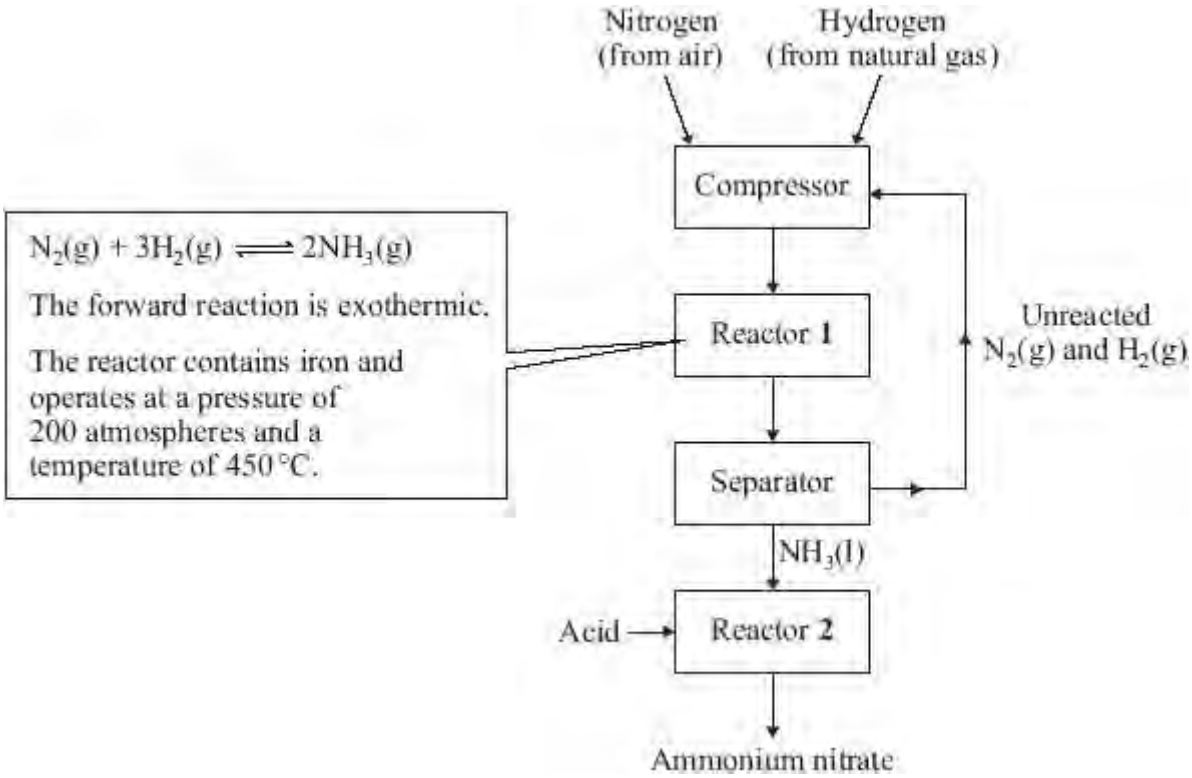
Q1. Ammonium nitrate is an important chemical. The diagram shows the main stages in the manufacture of ammonium nitrate.

Study the diagram and then answer the question.



(a) What is the purpose of the iron in reactor **1**?

.....

.....

(1)

(b) Explain why the best yield of ammonia at equilibrium is obtained:

(i) at low temperature

.....

.....

(1)

(ii) at high pressure.

.....

.....

(1)

(c) The temperature used in reactor **1** is 450 °C.

Explain why a much lower temperature is **not** used.

.....

.....

(1)

(d) A mixture of ammonia, nitrogen and hydrogen leaves reactor **1**.

In the separator, what is done to the mixture to separate the ammonia from the other gases?

.....

.....

(1)
(Total 5 marks)

Q2. Transition metals are useful as catalysts. Iron is used as a catalyst in the manufacture of ammonia.

$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$

(i) What is meant by $\rightleftharpoons$ in the chemical equation?

.....

.....

(1)

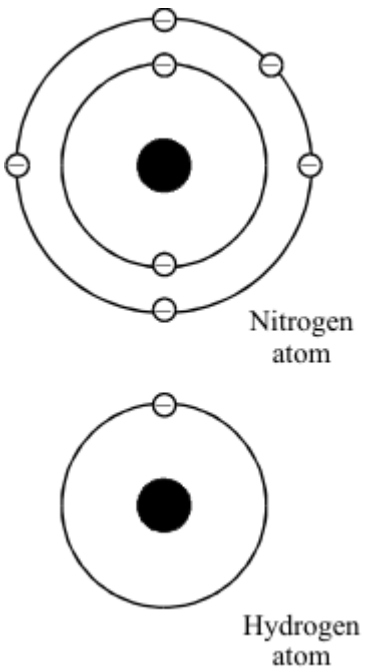
(ii) What would be the effect on the yield of ammonia if the pressure was increased?

.....

.....

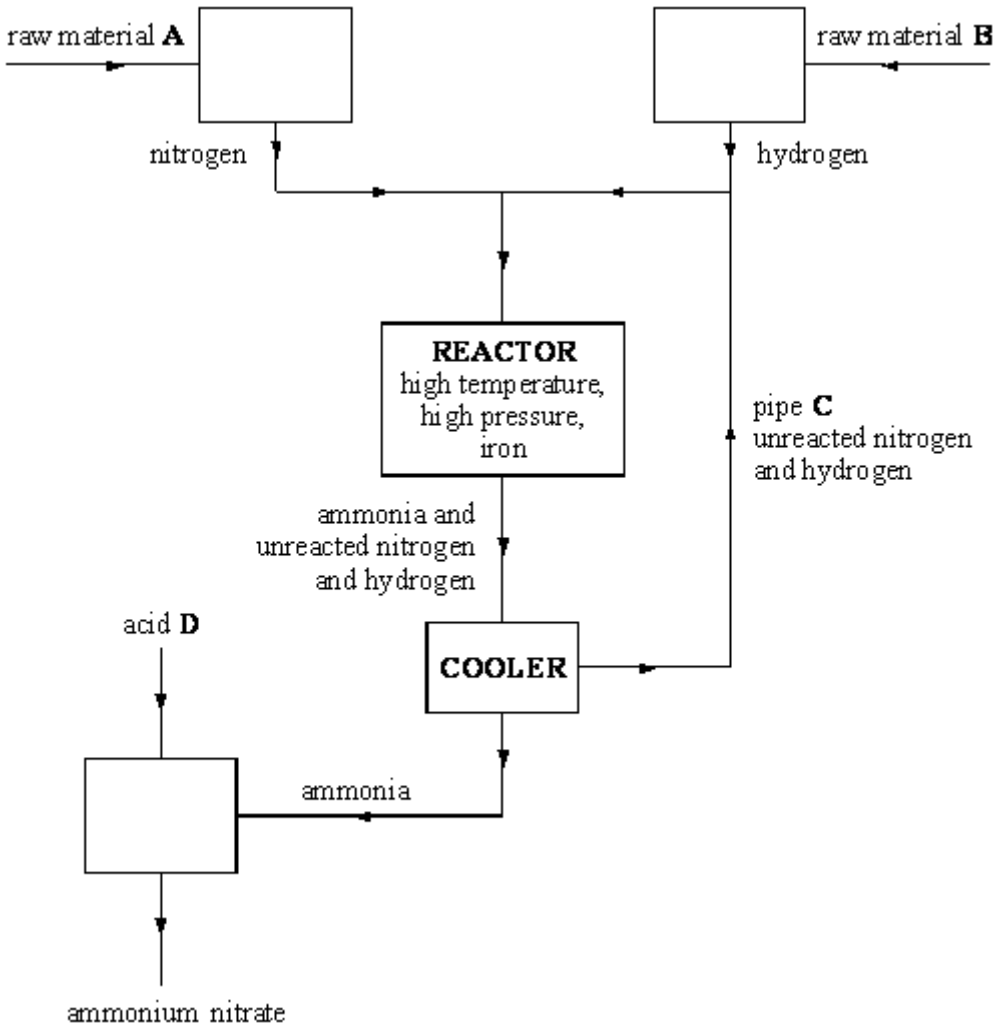
(1)

(iii) Draw a diagram to show the arrangement of the electrons in a molecule of ammonia. The electron arrangement of each atom is shown.



(1)
(Total 3 marks)

Q3. The flow chart below shows the main stages in the production of ammonium nitrate.



(i) Name the **two** raw materials shown in the flow chart as **A** and **B** by choosing words from the list.

air **coke** **limestone** **natural gas**

Raw material **A** .....

Raw material **B** .....

(2)

(ii) Complete the word equation for the reaction which makes ammonia.

..... + ... → ammonia

(1)

(iii) What is the purpose of the iron in the reactor?

.....

.....

(1)

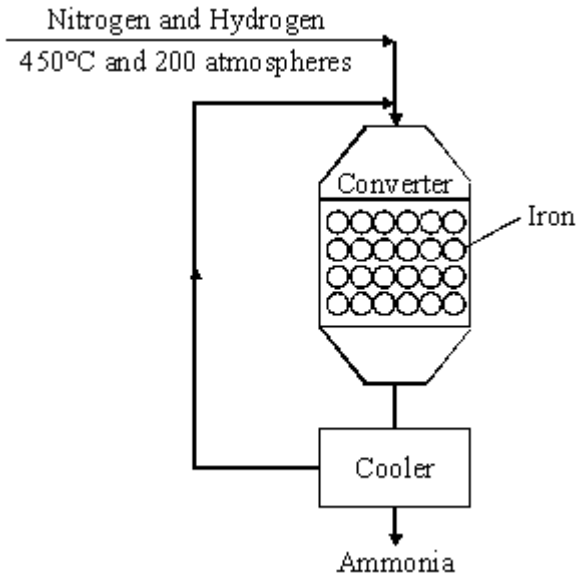
(iv) What is the purpose of pipe **C**?

.....

.....

(1)
(Total 5 marks)

Q4. The diagram shows the final stages in the manufacture of ammonia.



(a) Why is iron used in the converter?

.....

.....

(1)

(b) Write the word equation for the reaction in the converter.

..... + ... ⇌ .....

(1)

(c) The yield of ammonia is only about 15%.

(i) Why can the yield **not** be 100%?

.....

.....

(1)

(ii) Describe what happens to the mixture of gases after it leaves the converter.

.....

.....

.....

(2)
(Total 5 marks)

Q5. Hydrated copper sulphate is a blue solid. When it is heated, white solid anhydrous copper sulphate is made. This is a reversible reaction.

hydrated copper sulphate (blue) [+ heat energy] ⇌ anhydrous copper sulphate (white) + water

(a) To make the forward reaction work, the hydrated copper sulphate must be heated all the time.

What type of reaction is this?

.....

.....

(1)

(b) Anhydrous copper sulphate can be used in a test for water. What **two** things will happen when water is added to anhydrous copper sulphate?

1 .....

.....

2 .....

.....

(2)

(Total 3 marks)

Q6. (a) In industry ammonia is produced from nitrogen and hydrogen. The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

(i) What does the symbol (g) represent?

.....

(1)

(ii) What does the symbol $\rightleftharpoons$ represent?

.....

(1)

(iii) Nitrogen is used for the industrial production of ammonia. From what raw material does this nitrogen come?

.....

(1)

(iv) Hydrogen is used for the industrial production of ammonia. It is obtained from the reaction between methane and steam. The equation for this reaction is:

$CH_4 + H_2O \rightarrow 3H_2 + CO$

Explain how you can tell that this equation is balanced.

.....

.....

.....

.....

(2)

(b) Ammonia is used to make ammonium salts which can be used as fertilisers.

(i) Complete the names in the following sentence.

One example is ammonium ..... which is made by reacting ammonia with ..... acid.

(2)

(ii) All ammonium salts are soluble in water. Why is this a useful property of a fertiliser?

.....

.....

(1)

(c) Ammonia is a covalent, chemical compound.

(i) Complete the following sentence to describe a chemical compound.

In a chemical compound, two or more .....

.....

.....

(1)

(ii) What is a covalent bond?

.....

.....

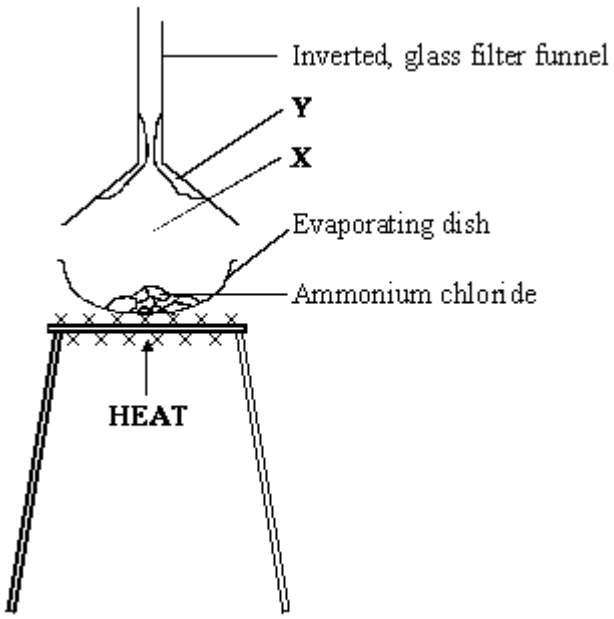
(1)

(Total 10 marks)

Q7. (a) The equation for the reaction that takes place when ammonium chloride is heated is:

$$\underset{\text{ammonium chloride}}{NH_4Cl(s)} \rightleftharpoons \underset{\text{ammonia}}{NH_3(g)} + \underset{\text{hydrogen chloride}}{HCl\ (g)}$$

The diagram shows how a teacher demonstrated this reaction. The demonstration was carried out in a fume cupboard.



(i) Apart from the gases normally in the atmosphere, which two gases would be at **X**?

..... and .....

(1)

(ii) Name the white solid that has formed at **Y**.

.....

(1)

(iii) Why was the demonstration carried out in a fume cupboard?

.....

.....

(1)

(iv) Complete the **four** spaces in the passage.

The chemical formula of ammonia is NH_3. This shows that there is one atom of ..... and three atoms of ..... in each ..... of ammonia. These atoms are joined by bonds that are formed by sharing pairs of electrons. This type of bond is called a ..... bond.

(4)

(b) Electrons, neutrons and protons are sub-atomic particles.

(i) Complete the **three** spaces in the table.

Name of sub-atomic particle	Relative mass	Relative charge
.....	1	+1
.....	1	0
.....	$\frac{1}{1840}$	–1

(2)

(ii) Which **two** sub-atomic particles are in the nucleus of an atom?

..... and .....

(1)

(Total 10 marks)

##

Ammonia is manufactured by the Haber Process, where nitrogen and hydrogen react together as follows:

$N_2 + 3H_2 \Leftrightarrow 2NH_3$

The reaction is reversible. A balance is eventually reached when ammonia is being formed at the same rate at which it is decomposing.

This point is called 'equilibrium'.

	PERCENTAGE OF AMMONIA AT EQUILIBRIUM		
PRESSURE (ATM)	100° C	300° C	500° C
25	91.7	27.4	2.9
100	96.7	52.5	10.6
400	99.4	79,7	31.9

(a) (i) What is meant by a 'reversible reaction'?

.....

.....

(1)

(ii) Which substances are present in the mixture at equilibrium?

.....

(1)

(b) (i) Under what conditions shown in the table is the maximum yield of ammonia obtained?

.....

.....

(2)

(ii) The Haber Process is usually carried out at a higher temperature than that which would produce the maximum yield. Suggest why.

.....

.....

.....

.....

(2)

(c) Ammonia can be converted into nitric acid in three stages:

Stage 1 Ammonia reacts with oxygen from the air to form nitrogen monoxide and water

$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$

Stage 2 On cooling, nitrogen monoxide reacts with oxygen from the air to form nitrogen dioxide.

Stage 3 Nitrogen dioxide reacts with water to form nitric acid and nitrogen monoxide.

(i) Describe the conditions under which the reaction in Stage 1 takes place.

.....

.....

.....

.....

(3)

(ii) Balance the equation for the reaction at Stage 2.

$NO \quad + \quad O_2 \longrightarrow NO_2$

(1)

(iii) Balance the equation for the reaction at Stage 3.

$NO_2 \quad + \quad H_2O \longrightarrow HNO_3 \quad + \quad NO$

(1)

(d) The chemical plant for manufacturing ammonia is often on the same site as plants manufacturing nitric acid and fertilisers.

(i) What advantages will this have for the manufacturing company?

.....

.....

.....

.....

(2)

(ii) Briefly describe **two** important ways in which it is possible to reduce the environmental impact of such plants on the surrounding area.

1 .....

.....

2 .....

.....

(2)
(Total 15 marks)