Reversible reactions and equilibria

Total marks : 17

Q1.

Figure 5 shows molecules of nitrogen, hydrogen and ammonia before the reaction and at equilibrium.

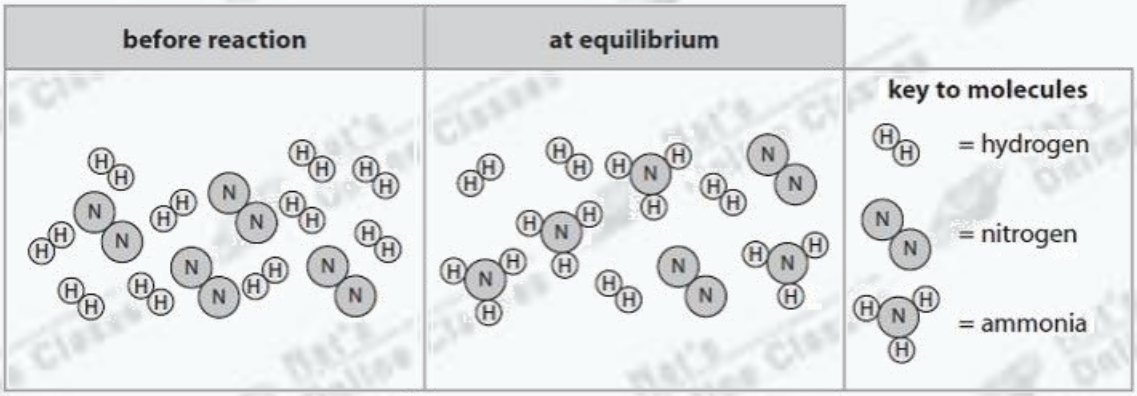

Figure 5

(i) Complete the table showing

- the number of hydrogen molecules before reaction
- the number of hydrogen molecules at equilibrium
- the change in the number of hydrogen molecules.

(1)

	number of molecules before reaction	number of molecules at equilibrium	change in number of molecules
nitrogen	4	2	–2
hydrogen	.....	.....	.....
ammonia	0	4	+4

(ii) Complete the equation for this reaction.

(2)

..... + ... ↔ 2 NH_3

(Total for question = 3 marks)

Q2.

In the Haber process, hydrogen and nitrogen react to form ammonia.

hydrogen + nitrogen $\rightleftharpoons$ ammonia

(i) The $\rightleftharpoons$ symbol in the word equation shows that the reaction goes forwards and backwards at the same time.

Give the name of this type of reaction.

(1)

.....

(ii) State the formula of a molecule of ammonia.

(1)

.....

(iii) Figure 7 shows a graph of world ammonia production, in millions of tonnes, from 1945 to 2015.

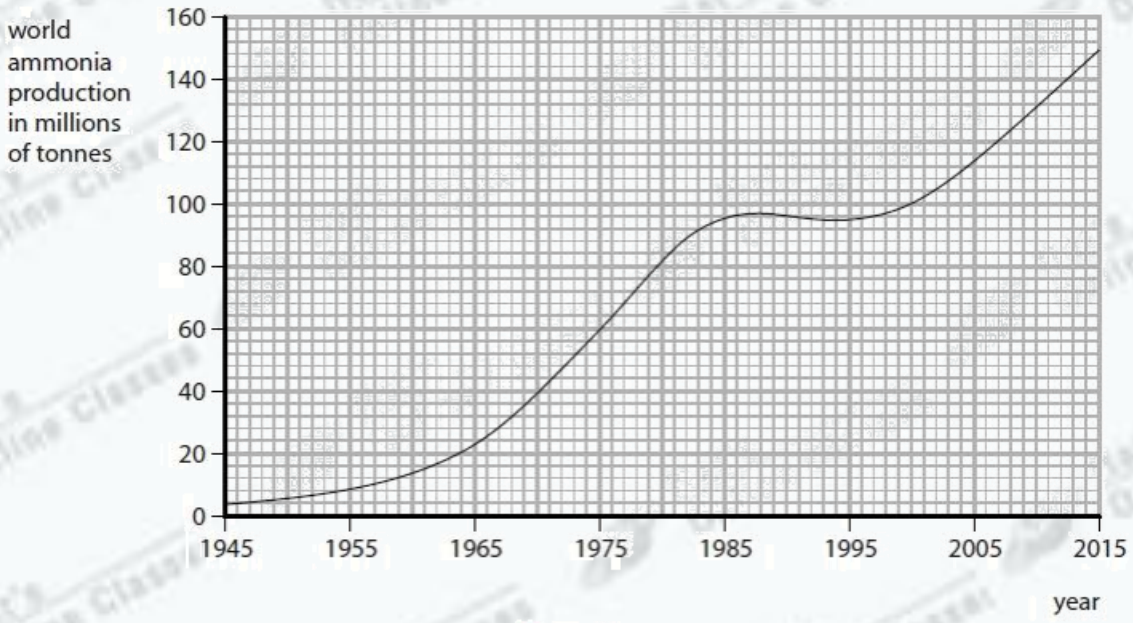

Figure 7

State the overall trend in world ammonia production from 1945 to 2015.

(1)

.....

.....

.....

(Total for question = 3 marks)

Q3.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Ammonia is manufactured by the Haber process.

The equation for the reaction is

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

The reaction is reversible and can reach equilibrium.

(i) An iron catalyst can be used in the reaction.

Which row of the table shows how adding the iron catalyst affects the rate of attainment of equilibrium and the equilibrium yield of ammonia?

(1)

	rate of attainment of equilibrium	equilibrium yield of ammonia
☒ **A**	increases	increases
☒ **B**	decreases	does not change
☒ **C**	decreases	increases
☒ **D**	increases	does not change

(ii) Which of the following statements is correct when the reaction reaches equilibrium?

(1)

☒ **A** the reverse reaction starts to take place
☒ **B** the amounts of nitrogen, hydrogen and ammonia are equal
☒ **C** the amounts of nitrogen, hydrogen and ammonia become constant
☒ **D** the reaction stops

(iii) The reaction is carried out at a pressure of 200 atmospheres.

Explain what effect a pressure higher than 200 atmospheres would have on the rate of attainment of equilibrium and on the equilibrium yield of ammonia.

(4)

.....

.....

.....

.....

.....

.....

(Total for question = 6 marks)

Q4.

Figure 1 shows the dot and cross diagram for a molecule of ammonia.

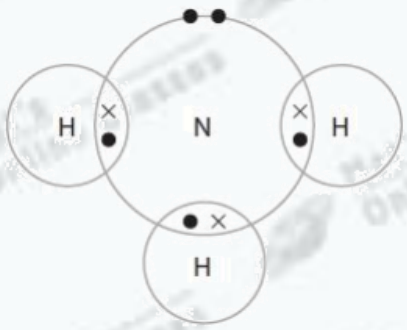

Figure 1

(i) Ammonia can be manufactured by the Haber process.

The word equation for the reaction is

nitrogen + hydrogen ⇌ ammonia

State the meaning of the ⇌ symbol.

(1)

.....

(ii) In the Haber process, the percentage yield of ammonia at equilibrium changes with temperature.

Figure 2 shows how the percentage yield of ammonia at equilibrium changes with temperature.

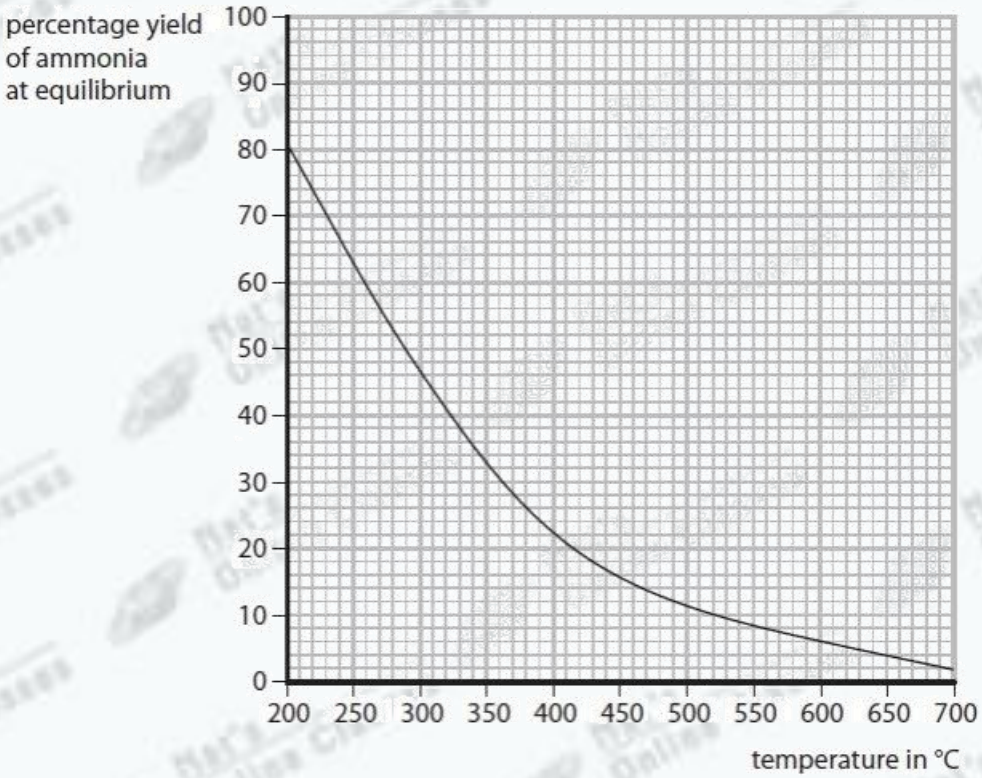

Figure 2

State what happens to the percentage yield of ammonia at equilibrium as the temperature increases.

(1)

.....

.....

iii) Use the graph to find the percentage yield of ammonia at equilibrium at 450°C.

(1)

percentage yield of ammonia at equilibrium = ...

(Total for question = 3 marks)

Q5.

When nitrogen and hydrogen are reacted together, the reaction can reach a dynamic equilibrium.

Use words from the box to complete the sentences about dynamic equilibrium.

(2)

backward	different	equal	faster	reversible

In a dynamic equilibrium two reactions occur at the same time.

These are the forward reaction and the ..... reaction.

The rates of the two reactions are .....

(Total for question = 2 marks)