

Reversible reactions and equilibria

Total marks : 17

Q1.

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

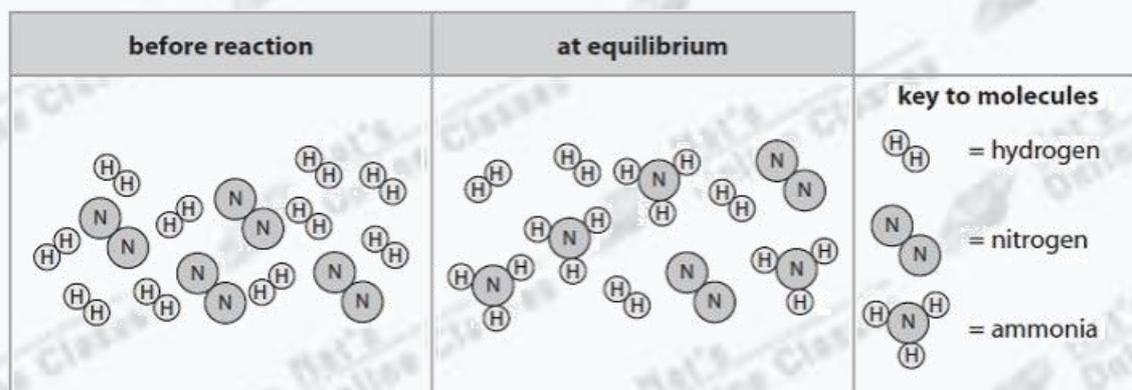


Figure 5

(i) Complete the table showing

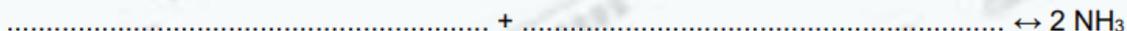
- the number of hydrogen molecules before reaction
- the number of hydrogen molecules at equilibrium
- the change in the number of hydrogen molecules.

(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)



(Total for question = 3 marks)

Q2.

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

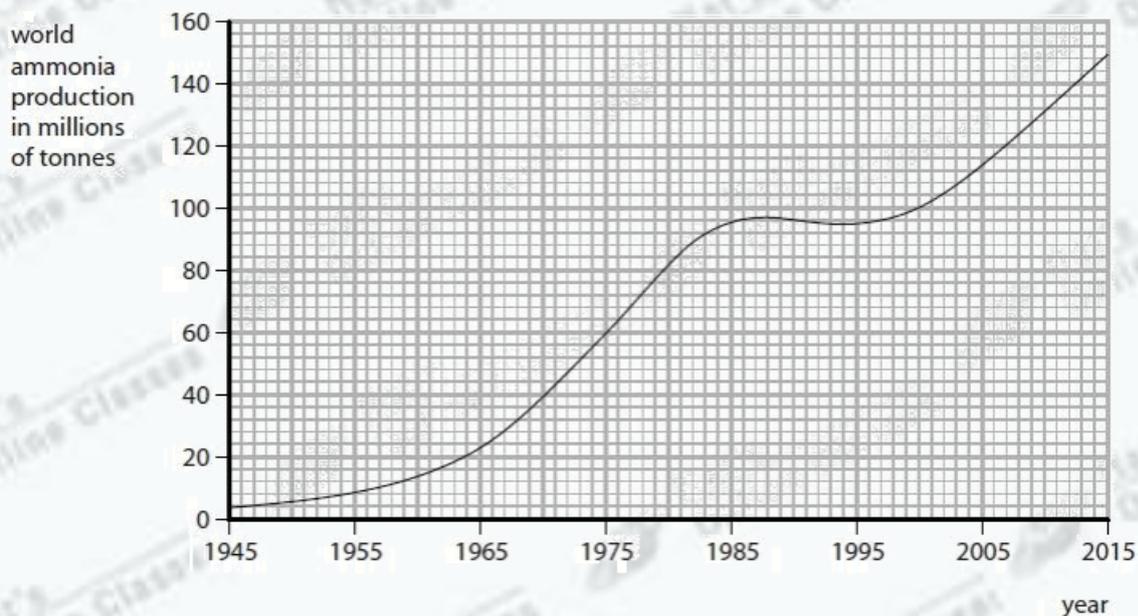


Figure 7

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

(1)

.....

.....

.....

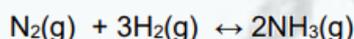
(Total for question = 3 marks)

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



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
<input type="checkbox"/> A	increases	increases
<input checked="" type="checkbox"/> B	decreases	does not change
<input type="checkbox"/> C	decreases	increases
<input checked="" type="checkbox"/> 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.

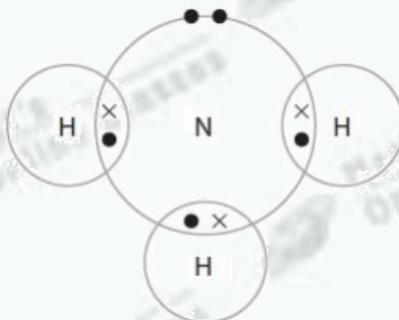


Figure 1

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

The word equation for the reaction is

nitrogen + hydrogen \rightleftharpoons ammonia

State the meaning of the \rightleftharpoons 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.

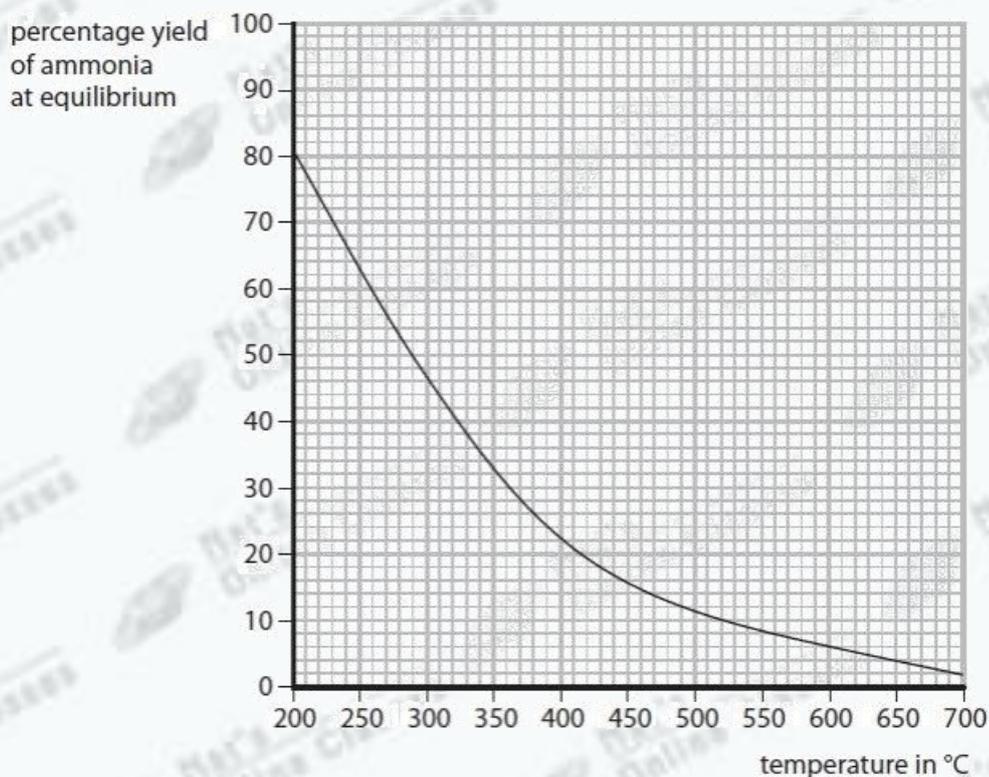


Figure 2

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
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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)

Mark schemes :

Q1.

Question number	Answer	Mark
(i)	hydrogen row: 10 4 -6	(1) AO2

Question number	Answer	Additional guidance	Mark
(ii)	$\text{N}_2 + 3 \text{H}_2 \rightleftharpoons 2 \text{NH}_3$ (2) Formulae of nitrogen and hydrogen (1)	balancing mark only if formulae correct	(2) AO2

Q2.

Question number	Answer	Additional guidance	Mark
(i)	reversible	allow equilibrium / equilibria /dynamic equilibrium ignore static equilibrium	(1)
(ii)	NH_3	allow H_3N reject NH_3, NH^3	(1)
(iii)	world ammonia production increases over time		(1)

Q3.

Question number	Answer	Mark
(i)	D increases does not change A, B, C are incorrect because catalysts increase rate of attainment of equilibrium and do not change equilibrium yield	(1)

Question number	Answer	Mark
(ii)	C the amounts of nitrogen, hydrogen and ammonia become constant A, B, D are incorrect because when the reaction reaches equilibrium the amount of nitrogen, hydrogen and ammonia remain constant	(1)

Question number	Answer	Additional guidance	Mark
(iii)	<p>an explanation linking</p> <ul style="list-style-type: none"> equilibrium attained in a shorter period of time / rate of attainment of equilibrium {faster/ increases} (1) equilibrium yield increases (1) equilibrium shifts to the {right / forward / to products side} (1) decrease in number of molecules (1) 	allow moves to fewer molecules	(4)

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	reversible (reaction) / reaction can go both ways	OWTTE allow reaction is happening forwards and backwards allow equilibrium	(1) AO 1 1

Question Number	Answer		Mark
(ii)	(the percentage of ammonia produced) decreases / goes down	allow goes lower	(1) AO 3 1a

Question Number	Answer		Mark
(iii)	any number between 15 and 16 inclusive		(1) AO 3 2b

Q5.

Question number	Answer	Mark
	backward (1) equal (1)	(2) AO1