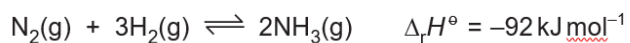


AS Level Chemistry B
H033/01 Foundations of chemistry

Question Set 1

- 1 (a) Ammonia is an important chemical used to make fertilisers. It is made in industry by the following equilibrium reaction.



Equation 1.1

Write down the value of $\Delta_r H^\ominus$ for $\text{NH}_3(\text{g})$.

Include the unit in your answer.

[1]

- (b) State what is happening to the forward and reverse reactions once equilibrium has been reached.

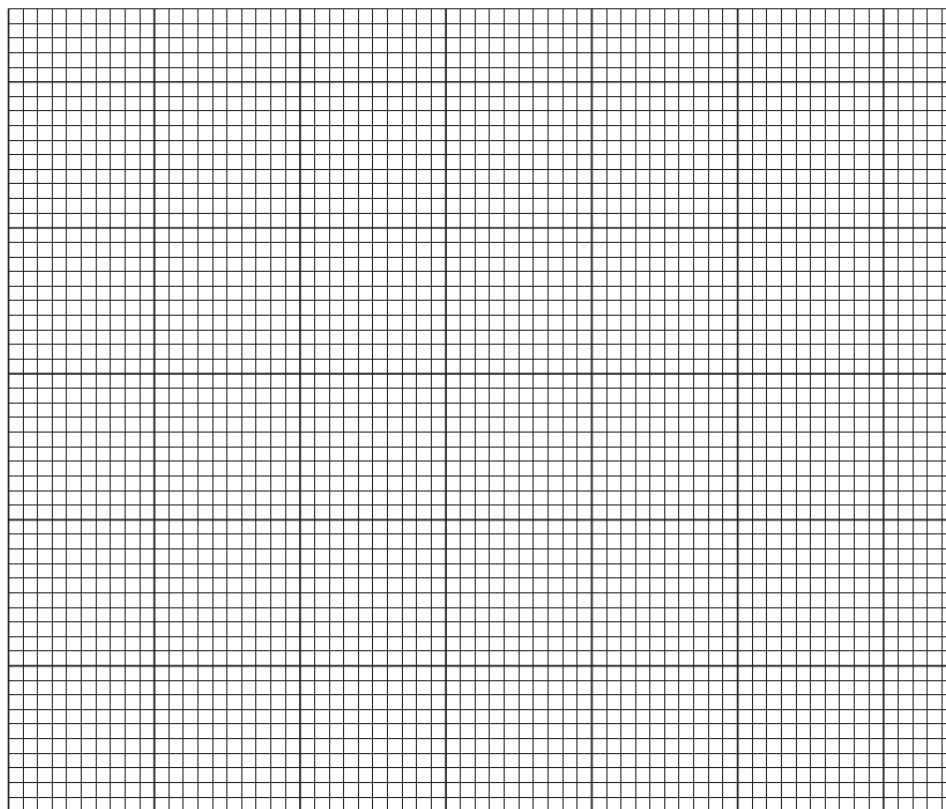
[1]

- (c) The data in the **Table 1.1** shows the equilibrium percentages of ammonia formed under different conditions of temperature and pressure in the presence of an iron catalyst.

	Temperature / K	
	473	673
Pressure / atm	Equilibrium percentages of ammonia	
10	50.7	3.9
25	63.6	8.7
50	74.0	15.3
100	81.7	25.2
200	89.0	38.8
400	94.6	55.4
1000	98.3	79.8

Table 1.1

- (i) On the graph paper below plot the results in **Table 1.1** and draw lines of best fit.



[3]

- (ii) How would the plot for 673 K be different if the iron catalyst had **not** been used?

Explain your answer.

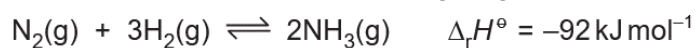
[2]

- (iii) Explain why the yield is greater at higher pressures.

[1]

- (iv) A student says that an industrial firm carrying out the reaction at 473 K would not use a pressure above 400 atmospheres.

Discuss the student's statement, giving reasons.



Equation 1.1

[2]

- (v) Ammonia is not often made at temperatures below 473 K. This is because the equilibrium is established too slowly at lower temperatures.

Explain why the rate of a reaction increases with temperature.

[2]

(d) The equilibrium shown in **equation 1.1** is set up.

The data below shows the composition of an equilibrium mixture at 473 K.

Equilibrium component	Equilibrium concentration/mol dm ⁻³
hydrogen	0.128
nitrogen	0.0403
ammonia	0.00271

Calculate the value of K_c for the reaction in **equation 1.1** at 473 K.

value of K_c = [2]

2

Some students research nitrogen oxides as air pollutants.

(a) Name the main polluting effect of NO₂ in the atmosphere.

[1]

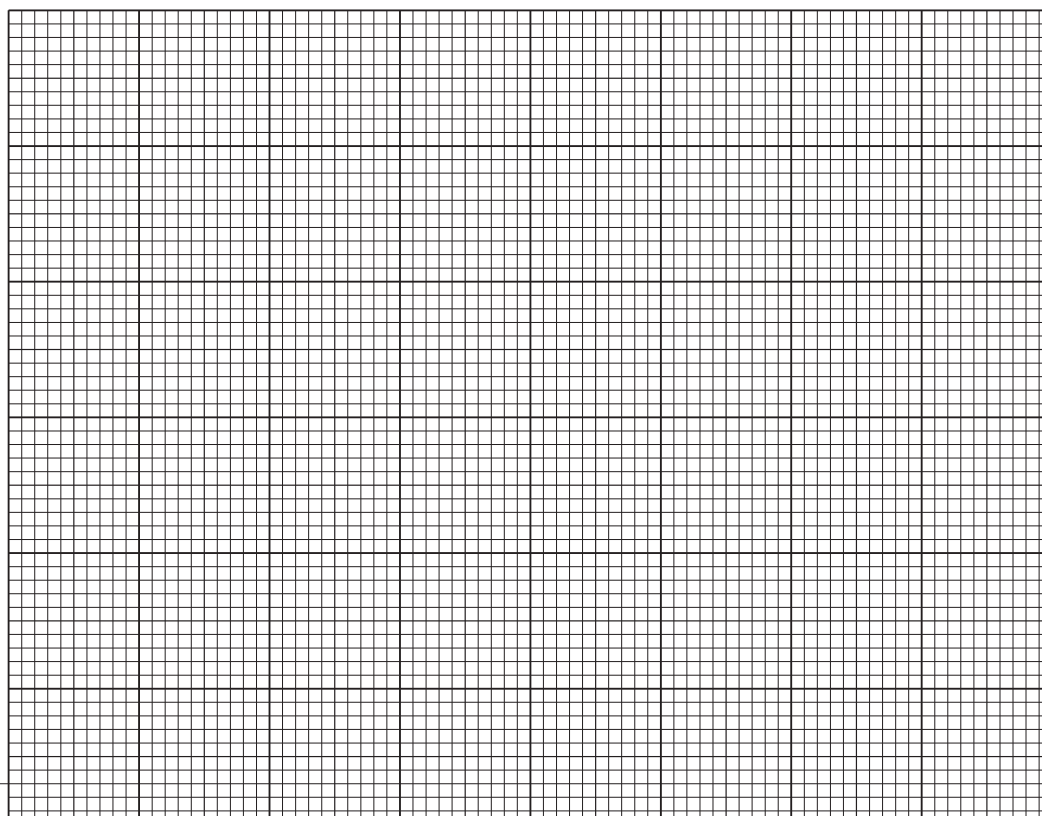
(b) The students look up some data for the experimentally measured rates of the reaction shown below.



Their data are shown in the table below.

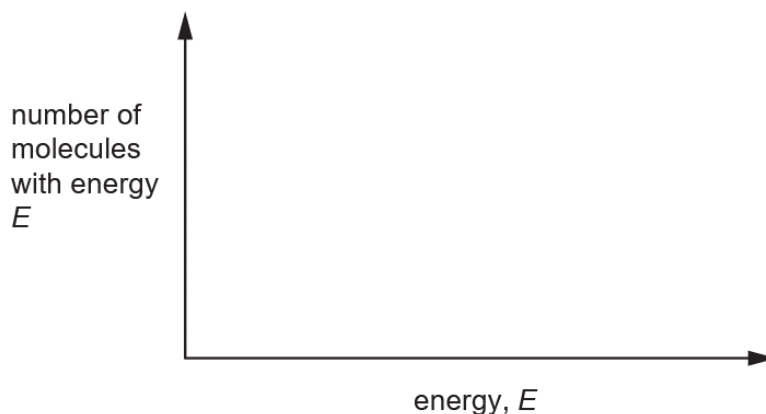
<i>T</i> /K	Relative rate
592	1.0
604	1.4
628	3.2
650	8.0
658	10.4

Plot a graph of relative rate against temperature and use it to work out the relative rate when the temperature is 615 K.



relative rate at 615 K = [3]

- (c) Draw two Boltzmann distributions at different temperatures on the axes below.
Use your diagram to explain why the rate of reaction increases with temperature.
Label your diagram.



- (d) The students then consider the reaction that occurs in lightning flashes: [3]

$$\text{N}_2 + \text{O}_2 \rightleftharpoons 2\text{NO} \quad \Delta_r H = +180 \text{ kJ mol}^{-1} \quad \text{Equation 24.1}$$

 (i) Complete the expression for the equilibrium constant, K_c , for this reaction.

$$K_c =$$

- (ii) A student says that, when equilibrium is reached in **equation 24.1**: [1]
- the rates of the forward and back reactions are equal
 - the concentrations of N_2 , O_2 and NO are equal.
- Comment on these statements, giving the correct chemistry where necessary.
- [2]
- (iii) Consider and **explain** the conditions of temperature and pressure that would give the greatest equilibrium yield of NO in **equation 24.1**.
- [5]

Total Marks for Question Set 1: 29

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