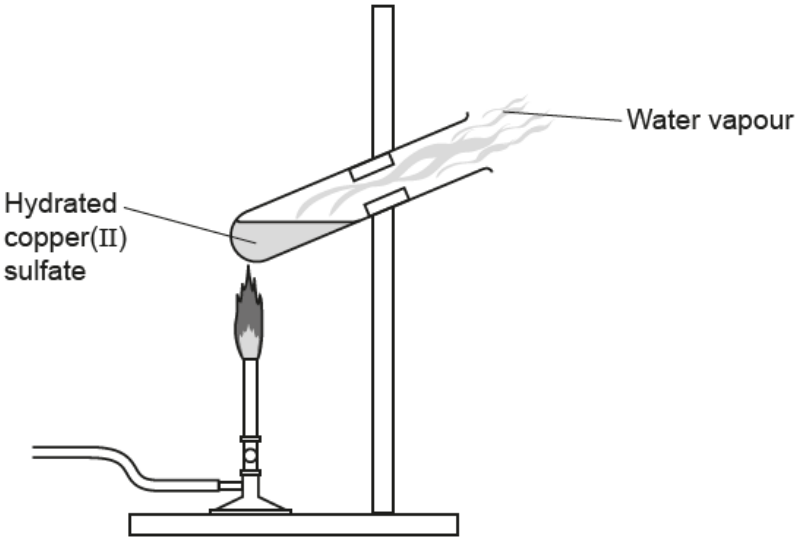
Equilibria – 2021/20 GCSE Gateway Chemistry Combined Science A

1. Nov/2021/Paper_J250/03/No.14

A student investigates heating hydrated copper(II) sulfate, $CuSO_4.5H_2O$.

The diagram shows the experiment they do.



The student:

- Measures the mass of a boiling tube.
- Puts about 5 g of hydrated copper(II) sulfate in the boiling tube and measures the mass.
- Gently heats the boiling tube for one minute.
- Lets the boiling tube cool down and measures the mass.

During the experiment the hydrated copper(II) sulfate turns from blue to white and water vapour is produced.

Look at the student's results.

Mass of boiling tube (g)	69.1
Mass of boiling tube and copper(II) sulfate **before** heating (g)	74.2
Mass of boiling tube and copper(II) sulfate **after** heating (g)	73.4

(a) Calculate the mass of water produced in the experiment.

Mass of water = ... g **[1]**

(b) The student expected a greater mass of water to be produced.

How could they improve the experiment so a greater mass of water vapour is produced?

.....

..... **[1]**

(c) Look at the equation for the reaction.

$CuSO_4.5H_2O(s) \rightleftharpoons$ ..... (s) + ... $H_2O(g)$

blue solid white solid

(i) **Complete** and **balance** the symbol equation. **[2]**

(ii) The student adds a few drops of water to a boiling tube containing some of the **white** solid.

Describe what the student observes happening to the white solid.

Give a reason for your answer.

Observation .....

.....

Reason .....

.....

[2]

(iii) As water reacts with the white solid, the temperature of the boiling tube increases.

What name is given to this type of reaction where heat is transferred to the surroundings?

..... **[1]**

2. Nov/2020/Paper_J250/04/No.3

The reaction to make sulfur trioxide, SO_3, is an example of a **dynamic equilibrium**.

The equation is shown below.

$2SO_2(g) + O_2(g)$ ..... $2SO_3(g)$

Which symbol completes the equation?

A $\rightarrow$

B $\leftarrow$

C =

D $\rightleftharpoons$

Your answer ☐ **[1]**

3. Nov/2021/Paper_J250/10/No.17

When a reversible reaction is left in a closed system, an equilibrium is reached.

(a) Look at the equation.

$2NO_2(g) \rightleftharpoons N_2O_4(g)$

It shows the equilibrium between $NO_2(g)$ and $N_2O_4(g)$.

(i) **Fig. 17.1** shows how the reaction rate of the forward and backward reactions change as the equilibrium is reached.

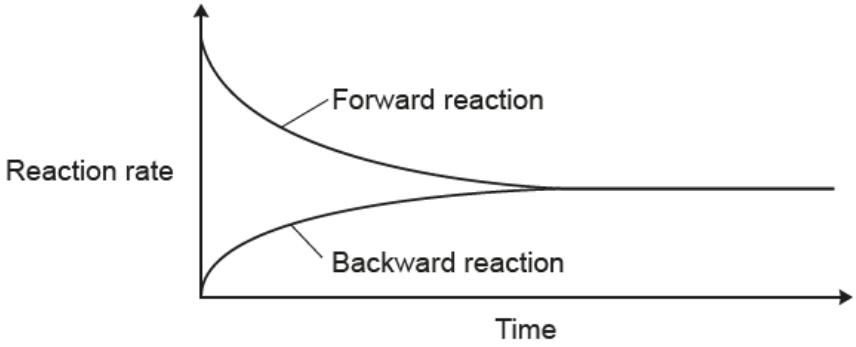


Fig. 17.1

Describe how **Fig. 17.1** shows that the equilibrium has been reached.

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..... **[1]**

(ii) **Fig. 17.2** shows how the concentrations of $NO_2(g)$ and $N_2O_4(g)$ change as the equilibrium is reached.

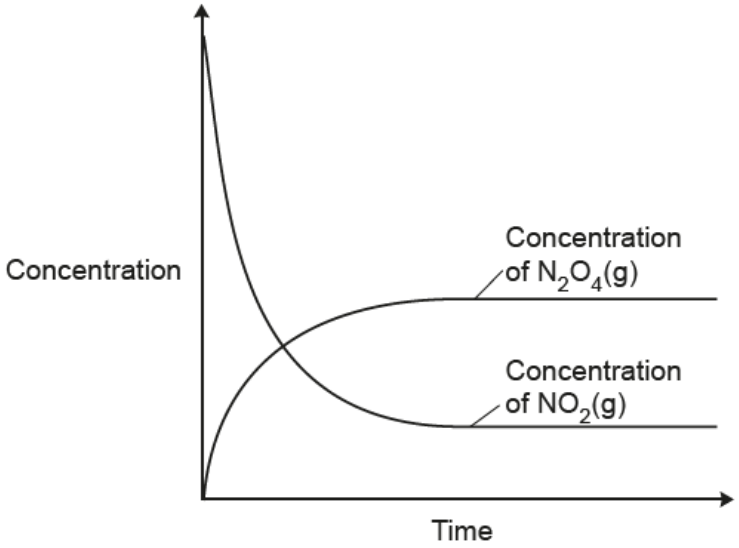

Fig. 17.2

Describe how **Fig. 17.2** shows that the equilibrium has been reached.

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..... **[1]**

(b) Each of the equations, **A**–**E**, shows a reversible reaction.

A $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ $\Delta H = +180\,kJ/mol$

B $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$ $\Delta H = -196\,kJ/mol$

C $2HI(g) \rightleftharpoons H_2(g) + I_2(g)$ $\Delta H = +10\,kJ/mol$

D $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92\,kJ/mol$

E $CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$ $\Delta H = +206\,kJ/mol$

ΔH shows the energy change of the **forward** reaction.

- If ΔH is negative the forward reaction is exothermic.
- If ΔH is positive the forward reaction is endothermic.

(i) Write the letter, **A**–**E**, of **one** equation where **more** product is formed when the temperature is decreased.

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[1]

(ii) Write the letter, **A**–**E**, of **one** equation where the amount of product is **unchanged** when the pressure is increased.

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[1]

(iii) Write the letter, **A**–**E**, of **one** equation where **more** product is formed when either the temperature is increased **or** when the pressure is decreased.

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[1]

4. Nov/2020/Paper_J250/10/No.16

Nitrogen and hydrogen react to form ammonia in a dynamic equilibrium.

$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$ $\Delta H = -92\,kJ/mol$

The table shows the amount of ammonia formed at different temperatures and pressures.

Pressure (MPa)	Amount of ammonia formed at different temperatures and pressure (%)				
	100 °C	200 °C	300 °C	400 °C	500 °C
2.5	92	64	27	9	3
5.0	95	74	40	15	6
10.0	97	82	53	25	11
20.0	98	89	67	39	18
40.0	99	95	80	55	32

Describe **and** explain how the percentage of ammonia formed changes with temperature and pressure.

Use the information provided in the table and your knowledge of reactions in dynamic equilibrium.

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..... **[6]**