Reference in textbook:
Book 5, Part XIII
Ch.52, p.14

Experiment 52.2

Determining the activation energy of the reaction between bromide ions and bromate ions

Objective

To determine the activation energy of the reaction between bromide ions, $Br^-(aq)$ and bromate ions, $BrO_3^-(aq)$.

$$BrO_3^-(aq) + 5Br^-(aq) + 6H^+(aq) \longrightarrow 3Br_2(aq) + 3H_2O(\ell)$$

Apparatus and Chemicals

Each group will need:

- Safety spectacles
- Protective gloves
- Beaker (250 cm^3)
- 3 measuring cylinders (10 cm^3)
- 10 boiling tubes
- 2 thermometers (–10°C to 110°C) (with a reinforced bulb)
- Magnetic stirrer-hotplate
- 2 stands and clamps
- Dropper
- Glass rod
- Stopwatch
- Phenol solution (0.01 M, 50 cm^3)
- A mixture of potassium bromide solution (0.083 M) and potassium bromate solution (0.017 M) (50 cm^3)
- Sulphuric acid (0.5 M, 25 cm^3)
- Methyl red indicator (10 cm^3)
- Distilled water
- Ice cubes

Chemical disposal:

- Dispose of the wastes into labelled waste bottles for different kinds of chemicals.

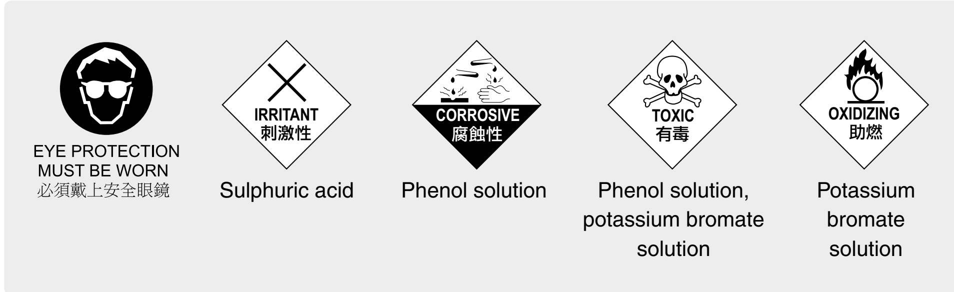
Time required:
2 periods

Procedure

Safety precautions

1. The experiment should be performed in a well ventilated laboratory as some toxic chemicals are used.
2. Wear protective gloves when handling corrosive chemicals.
3. Handle acids and corrosive chemicals with care. In case any acid or corrosive chemical gets into your eyes or onto your skin, report to your teacher immediately, and wash the affected area under running water for at least 3 minutes.

Name: ______________________ (   ) Class: ________ Group: ________ Date: ______________



Caution

Wear protective gloves when handling phenol solution.

1. (a) Using measuring cylinders, add 10 cm^3 of 0.01 M phenol solution and 10 cm^3 of a mixture of 0.083 M potassium bromide solution and 0.017 M potassium bromate solution to a boiling tube (tube *X*) (Figure 52.3a).

   (b) Using a dropper, add 10 drops of methyl red indicator to the tube *X* (Figure 52.3b).

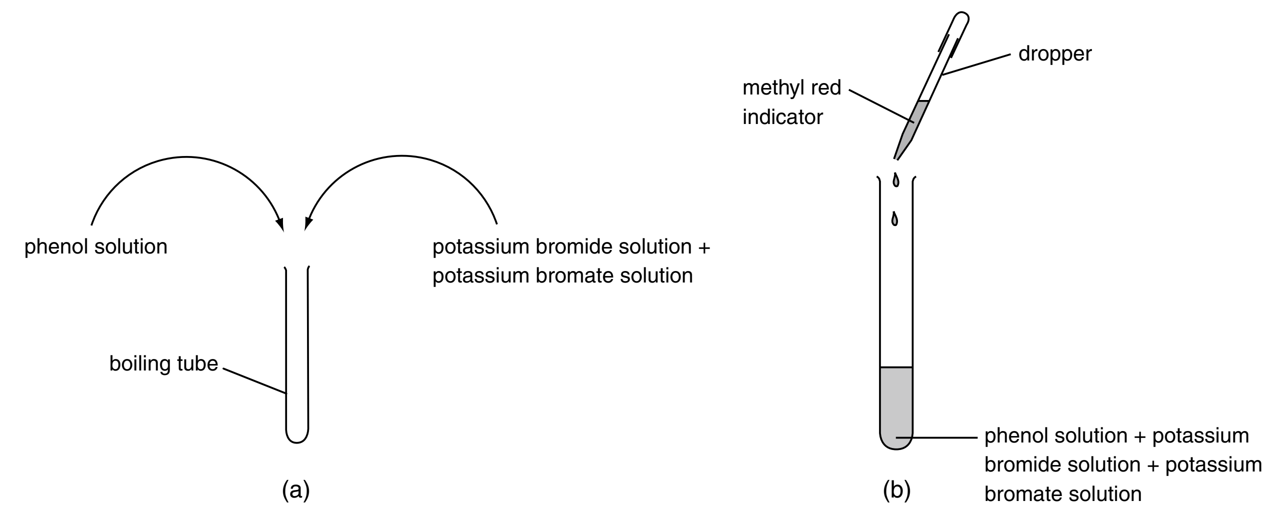


Figure 52.3

2. Using a measuring cylinder, add 5 cm^3 of 0.5 M sulphuric acid to another boiling tube (tube *Y*).

3. (a) Prepare a water bath by adding 200 cm^3 of water to a 250 cm^3 beaker and heat it to about 45°C.

   (b) Clamp the boiling tubes *X* and *Y* in a water bath.

   (c) Put a thermometer into each of the boiling tubes (Figure 52.4).

Name: ____________ ( ) Class: ________ Group: ________ Date: ____________

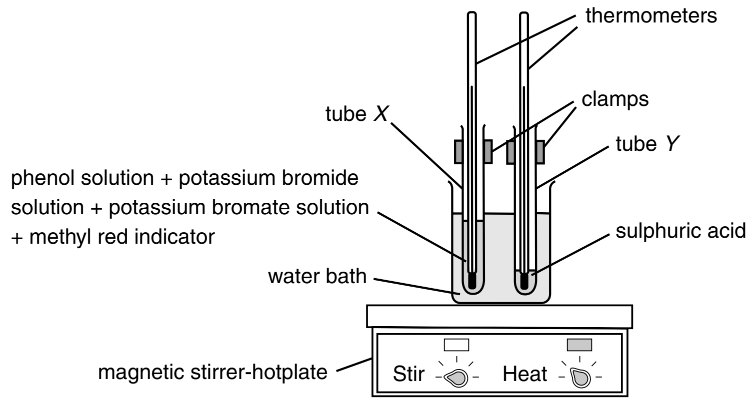


Figure 52.4

SBA note

In step 5, the reaction has not finished even when the red colour of the indicator has completely disappeared.

SBA note

The temperature of the water bath can be lowered by adding ice cubes to it, until the desired temperature is reached. However, it is not necessary for the temperatures to be exactly the same as listed (i.e. 25°C, 30°C, 35°C and 40°C).

4. (a) When the temperatures of the two solutions become steady and are approximately equal (e.g. 45°C), remove the thermometers in tubes *X* and *Y*, and pour the contents of tube *Y* into tube *X*.

   (b) Stir the mixture in tube *X* gently with a glass rod and start the stopwatch immediately. Put the thermometer into tube *X* after stirring.

5. When the red colour of the indicator has completely disappeared, stop the stopwatch. Record the time in **Table 52.3**.

6. Record the temperature of the mixture in **Table 52.3**.

7. Repeat steps 1–6 at temperatures close to 40°C, 35°C, 30°C and 25°C.

Results

8. Record the results in **Table 52.3**.

Temperature of reaction mixture (°C)					
Time for the complete disappearance of red colour of the indicator (s)					

Table 52.3

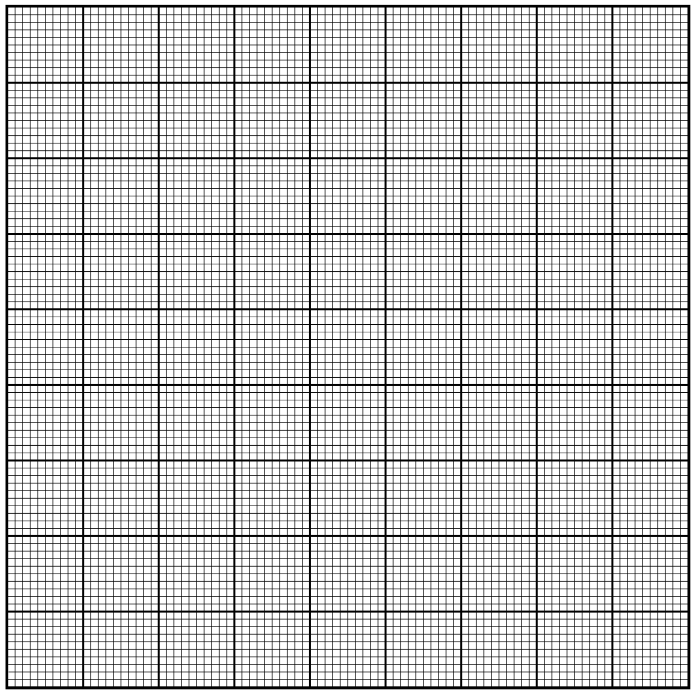
9. Write the logarithmic form of the Arrhenius equation.

10. (a) How is the rate constant of the Arrhenius equation related to the time taken for the disappearance of the red colour of the indicator in this experiment?

(b) Briefly describe how the activation energy of the reaction can be found graphically.

(c) Plot a graph using the method mentioned in (b) in **Graph 52.2** on the next page. Label the axes.

Before plotting the graph, construct a table in the space provided below using the results obtained in the experiment.



Graph 52.2

11. Calculate the activation energy of the reaction (in J mol^{-1}).
(Given: gas constant = 8.31 J K^{-1} mol^{-1})

Summary

12. The activation energy of a reaction can be found from the logarithmic form of the Arrhenius equation:

Questions

13. What is the purpose of adding the methyl red indicator in this experiment? (Hint: It does not act as an acid-base indicator as in a typical titration experiment.)

14. It is not suggested to attempt the experiment at a temperature as high as 80°C or above. Give a reason.

15. Explain the fact that a reaction with lower activation energy proceeds more rapidly.

(This is a blank page.)