Question 4 Planning: Measuring the activation energy for a reaction

(a) amount of phenol = 0.01 x $\frac{75}{1000}$ = 0.00075 mol

mass of phenol = 0.00075 x (6 x 12.0 + 6 x 1.0 + 16.0) = 0.0705 g

Procedure:

1. Using an analytical balance, weigh accurately about 0.0705 g of solid phenol in a clean and dry weighing bottle. Record the total mass of weighing bottle and solid.
2. Transfer all the phenol quantitatively to a 100 cm^3 beaker and dissolve it in some deionised water. Rinse the weighing bottle with small volumes of deionised water several times, adding each rinsing to the beaker.
3. Transfer the solution in the beaker quantitatively to a 75 cm^3 graduated flask. Rinse the beaker with small volumes of deionised water several times, adding each rinsing to the graduated flask.
4. Fill the graduated flask to the 75 cm^3 mark with more deionised water. Use the dropping pipette (or teat pipette or dropper) to add the deionised water drop-wise when nearing the mark.
5. Stopper the graduated flask and shake the solution thoroughly to ensure that it is homogeneous.

Safety issue: Phenol is corrosive and toxic by skin absorption.

Precaution: Wear gloves and goggles when performing the experiment.

(b) Procedure

1. Using separate 25 cm^3 measuring cylinders, add 15.0 cm^3 of 0.10 mol dm^{-3} KBr solution, 15.0 cm^3 of 0.2 mol dm^{-3} H_2SO_4 solution and 15 cm^3 of 0.01 mol dm^{-3} phenol solution (prepared from 4(a)) to a 250 cm^3 conical flask labelled reaction mixture. To this reaction mixture in the conical flask, add two drops of methyl red indicator.
2. Also, measure 15.0 cm^3 of 0.20 mol dm^{-3} $KBrO_3$ solution using another 25 cm^3 measuring cylinder.
3. Place this conical flask containing the reaction mixture and measuring cylinder containing $KBrO_3$ into a thermostatically controlled water bath set at 50 °C, with the reaction mixture immersed in the water bath.
4. Place a thermometer into the same conical flask.
5. When the temperature of the reaction mixture and $KBrO_3$ solution reaches 50 °C, add 15.0 cm^3 of 0.20 mol dm^{-3} $KBrO_3$ solution into the conical flask containing the reaction mixture placed in the water bath. Start the stopwatch and swirl the mixture thoroughly to mix its contents while keeping the mixture still immersed in the water bath.
6. Stop the stopwatch when the solution turns from red to colourless and record the time taken, t, for the solution to turn from red to colourless.
7. Repeat steps 1 to 6 four more times, each time with the temperature of the water bath in step 3 set at a different value of 10 °C, 20 °C, 30 °C and 40 °C.

Key Points:
- ✓ appropriate apparatus and capacity

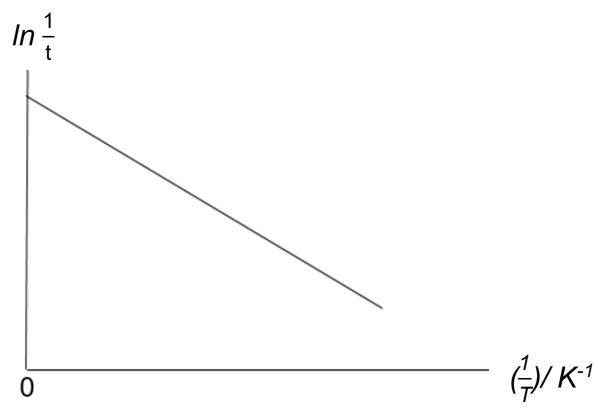
- ✓ appropriate volumes of KBr, $KBrO_3$, H_2SO_4, phenol and methyl red indicator
- ✓ starting stopwatch when $KBrO_3$ is added; stop stopwatch at end-point colour change and recording of time
- ✓ Incubating reaction mixture in a water bath with a thermometer
- ✓ Repeat procedure at different temperatures (at least 5)

Data manipulation

8. For each experiment (at different temperature), calculate ln $(\frac{1}{t})$ and corresponding $\frac{1}{T}$ where T is temperature in kelvin
9. Plot a graph of ln $(\frac{1}{t})$ against $\frac{1}{T}$ and find its gradient.
10. Since gradient $= -\frac{E_a}{R}$, $E_a = -$ (gradient) x R

Key Points:
- ✓ Plot a graph of ln $(\frac{1}{t})$ against $\frac{1}{T}$ and find its gradient
- ✓ Calculate $E_a = -$ (gradient) x R

(c)(i)



Explanation: (not needed as answer)

$ln\frac{1}{t} = -\frac{E_a}{R}(\frac{1}{T}) + c$

The graph fits the linear graph equation, y = mx + c.

Since both <u>E_a and R are positive</u>, the graph is a <u>downward sloping</u> straight line with a <u>negative gradient</u> of $(-\frac{E_a}{R})$ and a y-intercept of c.

(c)(ii) From the graph,

gradient $= -\frac{E_a}{R}$

$\therefore E_a =$ (gradient) (–R) = (gradient) (−8.31)