Experiment P08 Hydrogen bonding

Name: ________________

Seat No.: ______________

Date: _________________

Grade: ________________

Procedure:

Part A To discover the existence of hydrogen bonds between ethanol molecules

a. Using a measuring cylinder, add 10 cm^3 of ethanol into an insulated 50 cm^3 beaker, Measure the temperature of the liquid. **29 ^oC**

b. Then add 10 cm^3 of cyclohexane to the ethanol in the beaker, mix well and record the lowest temperature attained. **25 ^oC**

1. Why should the beaker be insulated?

   To prevent (reduce) heat lost to the surrounding.

2. Is the mixing process endothermic or exothermic?

   Endothermic.

3. Account for the temperature change.

   Breaking intermolecular hydrogen bonds between ethanol molecules require energy which is supplied by the mixture itself.

Part B To measure the strength of hydrogen bond formed between ethanol molecules

Repeat steps a and b in part A above using the same volume of ethanol but 25 cm^3 of cyclohexane. From the temperature drop estimate the hydrogen bond strength (in kJ per mole) in ethanol.

1. $\Delta T = 3\ ^oC$

$$\Delta H = (0.81 \times \frac{10}{1000}) \times 2.44 \times 3 + (0.78 \times \frac{25}{1000}) \times 1.83 \times 3$$

$$= 0.0593 + 0.1071 = 0.1664\ (kJ)$$

Mass of ethanol used $= 0.81 \times \frac{10}{1000} = 0.0081\ (kg) = 8.1\ (g)$

No. of moles of ethanol used $= \frac{8.1}{46} = 0.1761$

Hydrogen bond in ethanol $= \frac{0.1664}{0.1761} = 0.9446\ (kJ/mol)$

2. Comment on the reliability of the hydrogen bond strength obtained.

   (i) Some heat is absorbed from the surrounding, hence, the predicted value of hydrogen bond strength decreases.

   (ii) The hydrogen bond between ethanol molecules is not destroyed completely by cyclohexane, hence, the predicted value of hydrogen bond decreases.

   (iii) If the heat absorbed by the insulated beaker is omitted, the calculated value is lower than expected.

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Part C To discover the formation of hydrogen bond between molecules of ethyl ethanoate and trichloromethane

a. Measure 10 cm^3 of ethyl ethanoate into an 50 cm^3 insulated beaker. Record its temperature.
29 ^oC

b. Add to this 10 cm^3 of trichloromethane and mix well. Record the highest temperature attained. **36 ^oC**

1. Is the mixing process exothermic or endothermic? **Exothermic.**
2. Account for the temperature change.
   Energy is evolved because the formation of hydrogen bond between ethyl ethanoate and trichloromethane is exothermic.

Part D To estimate a value for the strength of hydrogen bond between ethyl ethanoate and trichloromethane

Repeat steps a and b in part C above using either one liquid in excess (Using 25 cm^3 trichloromethane). From the temperature change estimates the strength of the hydrogen bond formed between molecules of ethyl ethanoate and trichloromethane.

$\triangle T = 9$

$\triangle H = (0.9 \times \frac{10}{1000}) \times 1.92 \times 9 + (1.48 \times \frac{25}{1000}) \times 0.98 \times 9$

$= 0.1555 + 0.3263 = 0.4818$

Mass of ethyl ethanoate used = $0.9 \times \frac{10}{1000}$ = 0.009 (kg) = 9 (g)

No. of moles of ethyl ethanoate used = $\frac{9}{88}$ = 0.1023 (g)

Hydrogen bond between ethanoate and trichloromethane = $\frac{0.4818}{0.1023}$ = 4.7 (kJ/mol)