Experiment 9

Aim

A. To investigate the existence of hydrogen bonds between ethanol molecules.

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

C. To investigate the formation of hydrogen bonds between molecules of ethyl ethanoate and trichloromethane.

D. To measure the strength of hydrogen bond formed between molecules of ethyl ethanoate and trichloromethane.

Procedure

A.

1. 10 cm^3 of ethanol was added into an insulated 50 cm^3 beaker by using a measuring cylinder. The temperature of the liquid was measured.
2. 10 cm^3 of cyclohexane was added to the ethanol in the beaker. It was then mixed well and the lowest temperature attained was recorded.

B.

1. 10 cm^3 of ethanol was added into an insulated 50 cm^3 beaker by using a measuring cylinder. The temperature of the liquid was measured.
2. 20 cm^3 of cyclohexane was added to the ethanol in the beaker. It was then mixed well and the lowest temperature attained was recorded.

C.

1. 10 cm^3 of ethyl ethanoate was measured into an insulated beaker. Its temperature was recorded.
2. This was added to 10 cm^3 of trichloromethane and was mixed well. The highest temperature attained was recorded.

D.

1. 10 cm^3 of ethyl ethanoate was measured into an insulated beaker. Its temperature was recorded.
2. This was added to 10 cm^3 of trichloromethane and was mixed well. The highest temperature attained was recorded.

Result

Temperature change of solution

	A	B	C	D
Initial(^{o}C)	19.5	20.5	20	18
Final(^{o}C)	16	16.5	27	26
Net(^{o}C)	-3.5	-4	7	8

Calculation

Liquid	Formula	Relative Molecular mass	Density /kg dm^3	Specific heat capacity /kJ kg^{-1} K^{-1}
Ethanol	CH_3CH_2OH	46	0.81	2.44
Cyclohexane	C_6H_{12}	84	0.78	1.83
Trichloromethane	$CHCl_3$	119.5	1.48	0.98
Ethyl ethanoate	$CH^3CO^2CH^2CH^3$	88	0.9	1.92

B.

Mass of Ethanol: $0.81\times(10\times10^{-6})=0.0000081$kg

Mass of Cyclohexane: $0.78\times(20\times10^{-6})=0.0000156$kg

Total heat absorbed:

$4\times(0.0000081\times2.44+0.0000156\times1.83)$

$=0.000193248$ kJ

mole of limiting reactant (i.e. ethanol):

$0.0000081 \times 1000/46 = 0.000176086$ mole

The enthalpy change for one mole of ethanol that the hydrogen bond was broken is:

$0.000193248/0.000176086$

$= 1.09746$ kJ/mole

D.

Mass of ethyl ethanoate: $0.9 \times (20 \times 10^{-6}) = 0.000018$kg

Mass of trichloromethane: $1.48 \times (10 \times 10^{-6}) = 0.0000148$kg

Total heat absorbed:

$8 \times (0.000018 \times 1.92 + 0.0000148 \times 0.98)$

$= -0.000392512$kJ

mole of limiting reactant (i.e. trichloromethane):

$0.0000148 \times 1000/119.5$

$= 0.000123849$mol.

The enthalpy change for one mole of trichloromethane that formed hydrogen bond is:

$-0.000392512/0.000123849 = -3.1693$ kJ per mole

Conclusion

A. The mixing process between ethanol and cyclohexane is endothermic.

B. The enthalpy change for one mole of ethanol with hydrogen bond broken after mixed with Cyclohexane is 1.09746 kJ/mole.

C. The mixing process between ethyl ethanoate and trichloromethane is exothermic.

D. The enthalpy change for one mole of trichloromethane that formed hydrogen bond after mixed with ethyl ethanoate is -3.1693 kJ per mole

Discussion

A.

- The beaker should be insulated in order to prevent heat lost to surroundings.
- The temperature drops because there is hydrogen bonds between ethanol molecules and weaker van der waals' force between cyclohexane molecules. The mixing of the two liquid break the hydrogen bonds. As bonds are broken, energy is needed. Therefore, heat is absorbed and temperature drops.

B.

- Cyclohexane has to be used in excess in order to ensure that no hydrogen bond is presented.
- The hydrogen bond strength obtained was not accurate because there is heat lost to surroundings and to the beaker, which was not considered in calculation.

C.

- The temperature rises. During mixing, the electropositive hydrogen atom in trichloromethane formed hydrogen bonds with the electronegative oxygen atom in ethyl ethanoate. As bonds are formed, energy is given out. Therefore the temperature rises.

D.

- It does not matter whether using trichloromethane or ethyl ethanoate in excess because using trichloromethane or ethyl ethanoate in excess does not affect the no. of hydrogen bonds per molecule.