Evaporation and Intermolecular Attractions Lab

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**Purpose:**

The purpose of this lab was to study temperature changes caused by the evaporation of several liquids, relate the temperature changes and intermolecular force of attraction and predict and measure the temperature changes for several other liquids.

**Theory:**

Intermolecular Forces are relatively weak interactions that occur between molecules. There are three types of Intermolecular forces that are Dipole-Dipole, London Dispersion and Hydrogen Bonding. Dipole-Dipole forces orient themselves to maximize positive-negative interaction and minimize negative-negative and positive-positive forces. London Dispersion forces are the weakest of all intermolecular forces and exist primarily between noble gases and non-polar molecules. Hydrogen bonding is a special case of dipole-dipole forces and requires an H bond to an electronegative element. It is also the strongest of the bonds. All compounds have London Dispersion Forces and some have dipole forces (D/D and H/B). In this lab the rate of evaporation will be studied in an indirect way. Evaporation is an endothermic process. As a liquid evaporates it takes energy away from the object it is on. This means that the bigger the change in temperature of the object left behind, the faster the rate of evaporation and the weaker the intermolecular forces; the rate of evaporation of a liquid is inversely proportional to the intermolecular forces holding the liquid together. The organic compounds looked at in this lab were alkanes and alcohols.

The alkanes looked at were n-pentane and n-hexane. Along with carbon and hydrogen, the alcohols also contain the –OH functional group. The two alcohols were methanol and ethanol. The molecular structure of alkanes and alcohols was examined for the presence and relative strength of two intermolecular forces being hydrogen bonding and dispersion forces. The ΔT (t2–t1) values of the temperature probes evaporated from will be used to compare the intermolecular forces within the evaporated liquids.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Substance | Formula | Structural Formulas | Molecular Weight | Hydrogen Bond? |
| Ethanol | C2H5OH | H H  H–C–C–O–H  H H | 46.068 | Yes |
| 1-propanol | C3H7OH | H H H  H–C–C–C–O–H  H H H | 60.094 | Yes |
| 1-butanol | C4H9OH | H H H H  H–C–C–C–C–O–H  H H H H | 74.12 | Yes |
| n-pentane | C5H12 | H H H H H  H–C–C–C–C–C–H  H H H H H | 72.140 | No |
| Methanol | CH3OH | H  H–C–O–H  H | 32.042 | Yes |
| n-hexane | C6H14 | H H H H H H  H–C–C–C–C–C–C–H  H H H H H H | 86.172 | no |

**Procedure:**

**Data:**

|  |  |  |  |
| --- | --- | --- | --- |
| Substance | t1 (°C) | t2 (°C) | t (t1–t2) (°C) |
| ethanol | 24.68 | 11.32 | 13.36 |
| 1-propanol | 24.27 | 18.00 | 6.27 |
| 1-butanol | 24.41 | 21.35 | 3.06 |
| n-pentane | 24.43 | 2.74 | 21.69 |
| Methanol | 24.22 | 4.214 | 20.006 |
| n-hexane | 23.89 | 5.925 | 17.965 |

|  |  |
| --- | --- |
| Predicted t(°C) | Explanation |
| 5.3 | The temperature change for 1-butanol will be less than 6.27 because it has more IMF and a higher molecular weight. |
| 9.8 | The temperature change for n-pentane will be greater in temperature than 1-butanol because it has a lower molecular weight and its dipole-dipole bonding with no hydrogen bonds. |
| 18.14 | The temperature change for methanol will be higher than ethanol because it has one less carbon bond in its chain and it has hydrogen bonding. |
| 28.62 | The temperature change for n-hexane will have the greatest temperature because it has no hydrogen bonding and highest molecular weight, also six Carbons in its chain. |

**Calculations:**

t for ethanol t= (t1–t2)

t1=24.68 t= (24.68–11.32)

t2=11.32 t= 13.36

**Error Analysis:**

The predictions made compared to the actual results were fairly accurate. The numbers were somewhat off but the explanations were more accurate. For the 1-butanol the temperature prediction was only off by 2.24°C and the explanation was correct. For n-pentane, the temperature was off by 11.89°C and again, the explanation was correct. For Methanol, the temperature was off by only 1.86°C and the explanation was correct for the most part. The only thing missing was the fact that the lower molecular weight leads to a higher IMF. For n-hexane, the temperature was off by 10.655 °C and the explanation was incorrect. It was guessed to have the highest change in temperature but that was not exactly the right train of thought. It would have been better to say that the change in temperature would be lower than propanol due to the fact that even though hexane and propanol both lack hydrogen bonding, the higher molecular weight of hexane compared to pentane leads to a lower change in temperature than propanol.

**Conclusion:**

The purpose of this lab was fulfilled by testing and observing the different rates of evaporation among substances with differing molecular masses and/or hydrogen bonds. After experimenting, it observed that substances without hydrogen bonds ended with a smaller change in temperature. Also, the lower the molecular weight, the higher the change in temperature would be.

**Questions:**

1. Even though n-pentane and 1-butanol have molecular weights of 72 and 74, respectively,

1-butanol has a much smaller t due to the presence of hydrogen bonding between its

molecules. This results in a stronger attraction, and a slower rate of evaporation.

1. The 1-butanol has the strongest attractions between its molecules. Methanol has the

weakest attractions. The 1-butanol has the largest molecules and resulting strongest

dispersion forces. This gives it the lowest evaporation rate and the smallest t.

1. The n-hexane has the stronger attractions between its molecules. The n-pentane has the

weaker attractions. The n-hexane has the larger molecules and the resulting stronger

dispersion forces. This gives it a lower evaporation rate and the smallest t.