

Vapor pressure and heat of vaporization lab answers report

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Introduction

Heat of vaporization and vapor pressure are the two essential properties of a liquid in thermodynamics. The vapor pressure of a substance is the measure of the tendency of its molecules escaping (Blauch). The heat of vaporization is defined as the amount of the attractive energy that exists between molecules in the liquid and has to be overcome in order for the molecules enter the vapor phase. When a liquid sample is put into a container, there is the tendency for the liquid to evaporate. Liquid molecules escape from their state into the gaseous state. When the liquid is put in a closed container, the conversion from liquid to gas will tend to stop when the state of equilibrium is achieved (Kuwata).

In this experiment, the pressure inside a closed vessel with volatile liquids (methanol, ethanol and propanol) was measured over a range of temperatures, and the relationship between pressure and temperature determined. The heat of vaporization of the liquids was also calculated.

Methods

Safety measures such as wearing goggles, precautions against inhaling alcohol vapors, skin contact with the solvents were adhered to while doing the experiment. A hot plate was used to heat 200mL of water placed in a 400mL beaker. Water was prepared at room temperature water bath using a 1 liter beaker. The Connect a Gas Pressure Sensor was connected to Channel 1 of the Vernier computer interface and a Temperature Probe connected to Channel 2 of the interface. The interface was connected to the computer with the proper cable.

Using clear tubing, the white rubber stopper was connected to the Gas Pressure Sensor, and the white stopper snugly twisted into the neck of the Erlenmeyer flask. This was done to avoid losing any of the gas produced as the liquid evaporates.

Into the 20mL syringe, 3mL of methanol was drawn and the syringe thread onto the two-way valve on the white stopper. The Logger Pro program was started on the computer and the file " 34 Vapor" opened from the Advanced Chemistry with Vernier folder. Data collection was started by clicking the " collect" button. The first measurement was taken by placing the Temperature Probe near the flask. After the stabilization of the pressure and temperature readings, the " keep" button was clicked to record the readings.

Methanol was added into the flask and the valve below the syringe that contained the 3mL of methanol opened. The plunger of the syringe was pushed down to inject the 1-propanol and the valve closed immediately. The syringe was removed from the stopper, and the pressure and temperature monitored. The keep button was clicked after the readings had stabilized. Carefully the stoppered flask was moved to the 1 liter beaker of room-temperature water, and the Temperature Probe placed in the water bath, as well. The pressure and temperature were monitored, and the keep button clicked when the readings had stabilized. Using a dipper, a small amount of hot water, from the beaker on the hot plate, was added to warm the water bath by 3-5°C. The water bath was stirred slowly with the Temperature Probe, and the pressure and temperature readings monitored, and the keep button clicked when the readings had stabilized. Temperature was increased

by 3-5°C step wise until six trials were completed. After the six sets of readings were recorded, the valve was opened to release the pressure in the flask. The flask was removed from the water bath and the stopper taken off the flask. Methanol was disposed correctly.

Data collection was terminated by clicking the stop button. The pressure value of the first data point was recorded as P_{air} for Trials 1 and 2, for the second data point as P_{total} for Trial 2 and the remaining values as P_{total} temperature values for each trial were recorded accordingly. The apparatus were cleaned and dried and the procedure repeated first for ethanol and then for propanol.

Results and Calculations

The pressure values for each trial with their corresponding temperatures for methanol, ethanol, and propanol were recorded in Table 1, Table 2 and Table 3 below respectively. The initial pressure was taken to be the pressure of air in the flask (P_{air}). Using the gas law relationship below, the new air pressures were calculated and the result recorded in their respective tables. The P_{air} from Trial 1 was used as P_1 and the Kelvin temperature of Trial 1 as T_1 .

The total pressure in each flask, P_{total} , was the sum of P_{vap} and P_{air} for each trial. The P_{vap} values were obtained by subtracting P_{air} that was calculated above from P_{total} measured during the experiment.

Propanol

Graphs of P_{vap} versus Celsius temperature (Figure 1, 2 &3) and the natural logarithm of P_{vap} ($\ln P_{vap}$) against the reciprocal of Kelvin temperature ($1/T$)

were plotted (Figure 4, 5 &6).

Figure 1: A graph of methanol vapor pressure (mmHg) versus temperature (OC)

Figure 2: A graph of ethanol vapor pressure (mmHg) versus temperature (OC)

Figure 3: A graph of propanol vapor pressure (mmHg) versus temperature (OC)

Figure 4: A graph of the natural logarithm of methanol vapor pressure (mmHg) against the reciprocal of temperature

Figure 5: A graph of the natural logarithm of ethanol vapor pressure (mmHg) against the reciprocal of temperature

Figure 6: A graph of the natural logarithm of propanol vapor pressure (mmHg) against the reciprocal of temperature

The slope of the linear regression equation for the graph in figure 2 and the equation below were used to calculate ΔH_{vap} from the slope of the linear regression.

For methanol, the equation of the equation was $y = -5100. x + 21. 84$. The function ΔH_{VapR} is equal to -5100 and $R = 8. 31 \text{ J/mol}\cdot\text{K}$. Therefore,

$$\Delta H_{\text{VapR}} = -5100$$

$$\Delta H_{\text{Vap}} = -5100 * 8. 31 \text{ J/mol. K}$$

$$\Delta H_{\text{Vap}} = -42. 38 \text{ KJ/mol}$$

For ethanol, the equation of the equation was $y = - 3826. x + 16. 77$. The function ΔH_{VapR} is equal to -3826 and $R = 8. 31 \text{ J/mol}\cdot\text{K}$. Therefore,

$$\Delta H_{\text{VapR}} = -3826$$

$$\Delta H_{\text{Vap}} = -3826 * 8. 31 \text{ J/mol. K}$$

$$\Delta H_{\text{Vap}} = -31.8 \text{ kJ/mol}$$

For propanol, the equation of the equation was $y = -25040x + 84.64$. The function $\Delta H_{\text{Vap}}/R$ is equal to -25040 and $R = 8.31 \text{ J/mol}\cdot\text{K}$. Therefore,

$$\Delta H_{\text{Vap}}/R = -25040$$

$$\Delta H_{\text{Vap}} = -25040 \cdot 8.31 \text{ J/mol}\cdot\text{K}$$

$$\Delta H_{\text{Vap}} = -208.08 \text{ kJ/mol}$$

Discussion

The experiment aimed at determining the heat of vaporization of methanol, ethanol and propanol. Increase in temperature causes an increase in air pressure when the volume is maintained constant (Benn). Increasing the temperature of the solvent was expected to increase the pressure of the vapor above the solvent. As expected, the vapor pressure increased as temperature increased. This was clearly shown by the graphs of vapor pressure. Comparing the accepted values of ΔH_{vap} for each compound with the calculated values, there was a great difference. This could have been due to errors while doing the experiment.

Works Cited

Benn, D. I. Lecture 2: Air Pressure, Density and Temperature. 2013. 25 February 2013 .

Blauch, David N. Phase Changes: Vapor Pressure. 2009. 25 February 2013 .

Kuwata, Keith. Vapor Pressure and Heat of Vaporization. 2001. 25 February 2013 .