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Reading and Writing about Designed Events: The Experimental Sciences

Experimental sciences attempt to simplify the problems of observation by creating narrowly focused, carefully controlled events to generate specific types of data. Where applicable, experiments are powerful ways to develop and confirm knowledge. Experimental methods and laboratory techniques vary from field to field and problem to problem, but all experimenters share four features: they minimize personal factors, they measure precisely, they control extraneous factors, and they test theory. Familiarity with the format of the experimental report should aid you as you read and write within experimental scientific disciplines.

Controlling Events

The scientific experiment simplifies and focuses observations by simplifying and focusing the event itself. Because the experimenter designs the initial conditions (but not the results) of the event, he or she can control personal and other extraneous factors and can maximize precision of measurement. Moreover, the experiment can be designed to test a particular theory or hypothesis.

Not all events can be studied through experiment; for example, no one has yet been able to create an earthquake or a political revolution under laboratory conditions. Moreover, laboratory conditions may so distort some events that the experimental results, Stripped of natural complexity and context, may be misleading. Studies of writing done under laboratory conditions, for example, have been questioned because the artificial laboratory atmosphere both changes the behavior of the writers studied and divorces them from the reality of the writing task. Particularly in studying human behavior, experiments might not tell what you would want to know about behavior in naturally occurring situations. But for those situations where experimental techniques apply, experiments can provide definitive, focused tests of claims.

Experimental methods vary among disciplines and even among approaches within the same discipline. Particular research questions, objects under study, equipment, procedures, and modes of analysis lead to different criteria of precision and validity. What counts as an experimental fact in one discipline may be of little interest to another, understandably enough; somewhat more surprisingly, that same fact may not even be considered valid in another field—and not just because some disciplines may be more rigorous than others. A physicist may find it hard to accept certain results in experimental psychology because the results do not directly relate to a strong theoretical framework; at the same time, the experimental psychologist may find the physicist's results too dependent on a long chain of theoretical reasoning and not based on a large enough set of occurrences.

You will have to study long at the laboratory bench of an experimental discipline to be able to produce results that will be considered valid for that discipline. Experiments and experimental reports do, nonetheless, share common elements in all disciplines.

Experimental Methods

Minimizing Personal Factors

The best way to understand what scientific experiments try to achieve is to explore the limitations of ordinary observations. As pointed out earlier, an individual's observations are affected by the individual's beliefs, prejudgments, and interests. To some extent, a person will see what he or she expects to see or thinks he or she should see. In the first feature of conducting an experiment, therefore, the experimenter tries to minimize personal factors by establishing objective measures that can be recorded without requiring interpretation by the observer. Statistical counts, machine readings, chemical tests, and descriptions using a specified technical vocabulary all reduce the interpretive role of the observer. The results produced by such techniques are less likely to be criticized as "just one person's way of looking at things." The results of the experiment have even better claims to objectivity if other experimenters in other laboratories produce the same results when they repeat the experiment.

Measuring Precisely

Another problem in ordinary observations is the lack of precision of human senses and ordinary language. Imagine you are watching two crystals of about the same size dissolve in water, each in a separate beaker of about the same size, containing about the same amount of water. You see the first crystal vanish some time before the second. That tells you something, but not all that much. If you had various kinds of measuring instruments, from clocks, rulers, and scales to microscopes and spectrometers, you could find out much more about what was going on-not only about the time involved, but about the nature, size, and density of the crystals, as well as about the changes that took place when the crystals dissolved. Moreover, much of your data would be quantitative, allowing detailed comparison between the two samples, and perhaps allowing the use of formulae to make further calculations. Finally, the use of planned measures and standard instruments allows other trained observers to get similar results, which is preferable to relying on the individual judgment of each person. The use of instruments to take preplanned measurements extends the ability to observe precisely and thoroughly, provides quantitative data useful for detailed analysis, and allows data to be standardized.

Controlling Extraneous Factors

Decreasing personal interpretation and increasing precision of observation are only half of what experiments do. The third feature of a well-designed experiment puts in focus what is to be observed and attempts to eliminate other factors that would interfere with the results. In informal daily observation, many factors beyond what you are interested in knowing enter into what you see and feel.

Testing Theory

The fourth feature of an experiment is that particular variables isolated by the experiment have been chosen specifically because they test a particular theory. In order to test his theory that all objects fall at the same speed, Galileo is said to have designed the experiment of dropping two unequal weights from the top of the Tower of Pisa. The observation that the objects released at the same time did, in fact, land at the same time confirmed Galileo's hypothesis and contradicted an alternative hypothesis that heavier objects fall faster.

To test the hypothesis that obedience to authority is such a strong motivating force in many human beings that they will even follow orders to hurt strangers, Stanley Milgram set up a laboratory situation where subjects were ordered to administer strong--even lethal--electrical shocks to punish other human subjects. You may be happy to learn that the shocks were not real; on the other hand, you may be distressed to find Out that most people obeyed orders even past the point where their victims would have been killed had the shocks been real.[*] These experiments set up situations that are not like everyday circumstances in order to highlight only those unknowns that will test a particular theory--whether of gravity or of obedience.

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[*]Stanley Milgram, *Obedience to Authority: An Experimental View* (New York: Harper& Row, 1974), p. 35.

By these four methods—eliminating personal factors, increasing precision, controlling extraneous factors, and testing theory—experimenters drive reality to extremes not ordinarily experienced. Experiments are said to "twist the tail of nature" to make nature reveal its secrets. The conversion of matter into energy through atomic fusion, for example, although it is the Source of the sun's energy, is observable on earth only under the most extraordinary circumstances that have to be set up intentionally by physicists.

Reading and Writing Experimental Reports

Even though experimentation varies from field to field, a few general features of the writing of experimental results are common throughout most disciplines. Reports of experiments almost always include these steps: (1) a preliminary abstract, (2) a statement of the researcher's purpose and hypothesis (the introduction), (3) a description of procedure, materials, and apparatus (often entitled "Method"), (4) a report of results, (5) a discussion of the meaning of the results, and (6) a conclusion about the validity of the hypothesis and the implications for further study. Sometimes these parts are further broken down and expanded; sometimes they are presented in a continuous narrative. No matter what form they take, these parts are usually found in the experimental report.

The standard form of the experimental report: makes it easier both to read and to write than more open-ended forms of research writing. Once you know what section you are reading, you know what information is being presented and what function it serves in the article. If you need to check information, you know exactly where to go in the report. In fact, it is possible to read the article out of order, jumping from part: to part or even skipping parts, just because you know what the report form is.

Scientists frequently read experimental reports by initially skimming an abstract or summary that precedes the full text to see whether they are interested in reading more. If they decide to read on, they may read the first few lines of the introduction, where the problem is proposed, and the last few lines, where the contribution of the experimental study is stated. Then these readers will jump to the end of the report to find the full conclusions. If they remain interested, they will read backward into the discussion and results. Finally, if the article is very important to read in detail, they will scrutinize the methods section and review all the parts of the report more carefully.

As part of this methodical scanning of reports, scientists will often "black-box" (that is, skip over with no effort to understand) difficult or complicated sections. Only if they decide they really need to understand the experiment and the writer's argument fully will they open up the" black box" to read carefully the details inside.

When you write up an experiment, the standard format of the report allows you to write sections out of order. It may be easiest for you to describe your procedure or your results first, then go on to the discussion and conclusions before returning to the introduction. The opening abstract is often most easily written last.

However, the possibilities of reading and writing the experimental report in sections should not blind you to the overall logic tying the parts together. The methods are a logical consequence of the-problems being investigated; the results are a practical consequence of the methods; and discussion and conclusions grow out of the method and results in relation to the issues raised in the introduction. In some articles these connections are discussed explicitly, but elsewhere (he connections are left for the reader to infer, as in the study on page 270, of mothers' perceptions of children's stress.

The Abstract The abstract or summary provides an overview of the entire experimental report, particularly focusing on the special contribution (or “news") of the article. A brief description of the experiment, the most striking results, and most significant conclusions allows the reader to decide whether the article would be interesting to explore in greater detail. For more difficult and complicated articles, the abstract can serve as a kind of guide or outline to keep the reader oriented to the material. For these reasons, the abstract should usually be read first and written last. In reading, it tells you where you are going, and in writing, it helps you sum up what you have done.

The Introduction The introduction presents the background of previous work—in both theory and experiments—that led to the current hypothesis being tested. The hypothesis may be an original one or one taken from a previous researcher in the field. In college laboratory courses, you will usually be given a hypothesis to test; as you advance to more independent work, you will most likely have to develop hypotheses of your own. The introduction, which establishes the logic and purpose of the experiment in terms of prior work published in the field, helps the reader see exactly what the experiment is designed to prove.

The introductory section of experimental reports can, according to applied linguist John Swales, be seen as composed of four sections he terms “moves," each aimed at identifying and establishing the value of the contribution to be made by the article.*

MOVE ONE	Establishing the field a) by asserting the centrality of the problem, *or* b) by stating current knowledge
MOVE TWO	Summarizing previous research
MOVE THREE	Preparing for present research a) by indicating a gap in the research, *or* b) by raising a question about the research
MOVE FOUR	Introducing the present research a) by stating the purpose, *or* b) by outlining present research

In Move One, the introduction establishes that there is an important field or problem area to be investigated. Move Two summarizes what has already been established through previous research. Move Three, in order to warrant new research, identifies a gap or inadequacy in the research. Move Four indicates what the writer has done to fill the gap, which will be expanded upon in the body of the report. Through the series the writer

*John Swales, *Aspects of Article Introductions* (Birmingham, England; U of *Aston,* 1981).

creates general contexts within which the current report has meaning (the field, Move One, and the literature, Move Two), a particular space within which the report has importance (the gap, Move Three), and a particular task that the report promises to perform (the gap filler, Move Four).

In actual practice, as Swales and others have discovered, the order of the four moves may vary, especially if a report presents a series of experiments, addressing a sequence of gaps. In many cases as well, the fourth move may be left implicit, since the definition of the gap immediately implies what needs to be done, which obviously corresponds to the substance of the experiment as written in the article. Despite this variation, Swales's four moves can provide a very useful framework to use as you read experimental report introductions and as you write them.

The ""Method" Section The experimental design should be explained in the section on procedure, materials, and apparatus in order to indicate how the experiment isolates those factors to be measured and eliminates any possible interfering factors. The description of the experimental design should also indicate a method of observation and measurement that will achieve precision and decrease personal bias. Finally, the description should be clear and precise enough to allow another experimenter to re-create the experiment and confirm your results.

The Results The report of results should, of course, be as accurate as the experiment allows: you should indicate the degree of accuracy of your claims, and you should never claim to have found more than you actually did find. In some cases a narrative of the actual progress of the experiment helps put the results in better perspective.

The Discussion The results, however, are not sufficient in themselves; they must be discussed and interpreted. What kinds of patterns emerged? Were the results as anticipated? Were there any anomalies? How do these results compare with those of previous experiments? How strongly do the results support or contradict the original hypothesis? Do they suggest another theoretical possibility? Would information from another kind of experiment or a repeat of this one be useful in verifying the hypothesis further? Answers to these and similar questions will draw out the full meaning of the experiment and contribute to advancing knowledge in the field.

The Conclusion In organizing information outward from the specifics of the experimental results to a comparison with other published findings and then to conclusions about the original issues or problem, the concluding parts of a report reverse the organization of the introduction. The introduction moves *in* from the general problem to the literature to the specific research; the concluding section moves out from the specific research to its wider implications. Just as the introduction identifies a gap that current research fills, the conclusion integrates the research into the knowledge of the field.

Thus, although researchers may, to the uninitiated, seem to gain knowledge entirely on the basis of firsthand experience, the experiments make sense only in a framework of theory, verification, and criticism presented in the literature of the field. Study of published research helps the new researcher define problems that need investigation and provides the information necessary to carry on that investigation profitably. Afterward, the research report connects the results of the experiment with the rest of what is known in the field, making the work available for future researchers. In this way scientists build on one another's work—checking and developing the findings of all the separate researchers.

AN EXAMPLE: MOTHERS' PERCEPTIONS OF CHILDREN'S STRESS

The following survey research, although not done in the laboratory, creates within a questionnaire a controlled situation for the participants to respond to, and therefore has many of the characteristics of an experimental report. The study, reported in the journal *Sex Roles,* examines how mothers evaluate the effect of stress on male and female children. Although social stereotypes generally portray boys as not being as upset about difficulties as girls, research has demonstrated quite the opposite, that boys are psychologically more vulnerable than girls. The question tested in this experiment was whether mothers would be more influenced by social stereotypes or by the actual behaviors of children. It turns out, at least in this case, that mothers know best.

The article follows the format recommended in the *American Psychological Association Publication Manual* for both article organization and references (see page 217). In accordance with the manual's recommendations, the article is headed by an abstract and then contains the standard parts of the research report, identified by subheadings (except for the untitled introduction and review of the literature). The report of methods is broken down into several sections.

The report of results contains not only statistics of the findings (Mean Reported Stress Levels—M), but statistics analyzing the relationships among the variables, indicated by the F (1, 76) numbers. Finally, additional numbers indicated how consistent (SD) and reliable (p) the results are. Statistical methods are essential to many disciplines; if you pursue any subject that uses numbers (including business and economics as well as experimental disciplines), you will probably take at least one course in statistics. The proper use and honest presentation of statistics are as essential a pan of the subject as individual statistical techniques.

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READING STUDY QUESTIONS

1. On the basis of the abstract of “Children's Vulnerability to Stressful Life Events in Mothers' Eyes: Effects of Gender and Parental Experiences," explain the major findings of the study.

2. What kinds of previous research have previously been done on the subject of stress in boys and girls? What have been the findings of this research? What puzzle is posed by putting together the different kinds of prior research? '

3. What were the two issues authors Michael Hoffman and Rachel Levy-Shiff wanted to address in this study? What results did they hypothesize they would get? To what extent did the actual results correspond with the authors' hypotheses?

4. How do the methods provide accurate tests of the hypotheses? What details of the experimental designs serve to minimize personal factors and control extraneous factors?

5. What techniques are used to make results precise?

6. How does the discussion relate to the experimental results? What overall conclusions does the discussion section develop?

7. Identify the introductory section. In this introduction, which sentences correspond to each of the four moves identified by John Swales on page 268? Which of the four moves are presented most directly and fully, and which are presented most briefly and indirectly?

8. What part of the article did you have to "black-box" because you could not understand technical details?

9. Compare the abstract with the entire article. What aspects of the article does the abstract emphasize? What aspects does the abstract omit? Why?

A STUDENT EXAMPLE: A FIRST YEAR CHEMISTRY LAB

Student laboratory experiments in first- and second-year courses often follow closely directions of laboratory manuals, which in turn are linked to course textbooks. Thus much of the background of theory, related findings, and interpretation is handed to the student, as is the specific procedure of the experiment. Moreover, since most of the experiments repeat well-known findings, there is usually little surprise to be found in the results. The experiments are more to help the students develop an understanding of how the principles work out in actuality, learn skills of laboratory work, and learn how to report what goes on in the laboratory.

To focus these learning activities, student experimental reports are often highly constrained, having to follow set outlines and questions as set out in the laboratory manuals. Often the reports of the experiment are skeletal, as so much of the surrounding meaning comes from the manuals and classroom. The introduction and review of the literature may vanish almost entirely into the textbook discussion. The methods and procedure may become a list of fixed instructions copied from the manual. The results may be presented in a schematic format. The discussion may become a fill-in-the-blank set of calculations and question answers, and the conclusion may be little more than a repetition of the general principle being demonstrated.

Nonetheless, the reports still follow the basic outline of standard experimental reports, as in the following first-year chemistry lab prepared by Jessica Mills and her partner, based on the instructions for Experiment 13 from the laboratory manual *Laboratory Experiments for General Chemistry* by Harold Hunt and Toby F. Block, reproduced here.

Experiment 13
The Vapor Pressure of Water

Laboratory TIme Required:	Two hours. May be combined with Experiment 14.
Special Equipment and Supplies:	Thermometer Ice
Safety:	This experiment involves moving a beaker full of hot water. Always remain alert and be cautious when handling hot water. Never leave a burner flame unattended.
First Aid:	You may soothe burnt fingers by immersing them in cool water. Seek medical attention for serious burns.

Although phase changes are not chemical changes, the examination of phenomena such as vaporization is an important part of the study of chemistry. A liquid's volatility, enthalpy of vaporization, and normal boiling point are characteristics that reflect the intermolecular forces present in the liquid. This experiment employs simple apparatus in the study of a one-component system, water. Experiment 14 employs the same techniques, in scaled-down apparatus, to study vaporization of a two-component system.

PRINCIPLES

The atoms and molecules of any liquid are in constant motion, constantly changing their molecular speed and kinetic energy as a result of collisions. At any given temperature, a number of molecules may have sufficient kinetic energy to escape from the liquid at the surface, evaporating into the space above the liquid. Consequently, the particles remaining in the liquid have lower kinetic energy, and the temperature of the liquid decreases. If the liquid is in an open container, allowed to absorb heat from the surroundings to maintain a constant temperature, evaporation will continue until no more liquid remains. If, however, the liquid evaporates in a closed container, an equilibrium is established in which the rate of escape from the liquid is balanced by the rate at which gas phase particles lose energy and return to the liquid phase. The pressure exerted on the walls of the container when equilibrium has been established is called the equilibrium vapor pressure of the liquid.

The value of the equilibrium vapor pressure increases with temperature for all liquids. When the vapor pressure reaches the value of the external pressure, the liquid boils. The temperature at which the vapor pressure equals 760 torr (one standard atmosphere) is called the normal boiling point of the liquid.

In this experiment, you will study the relationship between the vapor pressure of water and temperature by monitoring the volume of an air bubble that is surrounded by a water bath. At temperatures above 5°C, water has an appreciable vapor pressure and Dalton's Law of Partial Pressures is used to relate the partial pressure of air, the vapor pressure of water, and atmospheric pressure (see Equation 13.1).

$$P_{atm} = P_{air} + P_{H20} \qquad (13.1)$$

At temperatures below 5°C, me vapor pressure of water is negligibly small. Therefore, at low temperature, the bubble may be considered to contain only air. The Ideal Gas Law can be used to relate the amount of air *(n_{air})* to the volume *(V)* of the bubble, the bath temperature *(T),* and the atmospheric pressure *(P),* as shown in Equation 13.2.

$$n_{air} = \frac{PV}{RT} \quad T<278\text{K} \tag{13.2}$$

At temperatures above 5°C, the bubble becomes saturated with water vapor. However, the amount of air contained in the bubble is constant. The Ideal Gas Law can be used once again to obtain the partial pressure of air *(Poi,)* from the number of moles *(n_{air})* of air in the bubble, the volume (V) of the bubble, and the bath temperature (1), as shown in Equation 13.3.

$$P_{air} = \frac{n_{air}RT}{V} \quad T>278\text{K} \tag{13.3}$$

The value of P_{H2O}, the vapor pressure of water, is then obtained from Equation 13.1. Once the values for the vapor pressure at different temperatures have been obtained, they can be used to find two characteristic · properties of water—its normal boiling point and its enthalpy of vaporization ΔH_{vap}. The enthalpy of vaporization is the heat that must be supplied to evaporate a mole of water at constant pressure. The relationship of ΔH_{vap} to the vapor pressure at different temperatures is given in Equation 13.4, where P_1 and P_2 represent the vapor pressure of water at temperature T_1 and T_2, respectively. The symbol "In" denotes the natural logarithm. The constant, R, is the ideal gas constant with the value of 8.314 joule/K mole rather than the value 0.08206 L atm/K mole, which would be used in Equations 13.2 and 13.3.

$$\ln P_2 - \ln P_1 = \frac{-\Delta H_{vap}}{\text{R}}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \tag{13.4}$$

The value of ΔH_{vap} is obtained by plotting In P versus $1/T$. Such a plot should be a straight line, with slope equal to $-\Delta H_{vap}/R$. Once ΔH_{vap} has been obtained, one may solve the equation to find the value of T at which P would equal 760 torr.

PROCEDURE

Obtain a 10-mL graduated cylinder and a beaker large enough for the cylinder to be submerged in it. Fill the beaker half full with distilled water. Put enough distilled water in the 10-mL graduated cylinder to fill the cylinder to 90% capacity (ignoring graduations). Place your finger over the mouth of the graduated cylinder and invert the cylinder in the beaker. An air bubble, 4 to 5 mL in volume, should remain in the cylinder. Add distilled water until the graduated cylinder is covered completely. Heat the water in the beaker to 75 or 80°C. The air sample should be allowed to extend beyond the calibrated portion of the cylinder without escaping. Remove the beaker from the heat when the desired temperature has been reached. Start recording the volume of the bubble and the water temperature when the air sample is contained completely within the calibrated portion of the cylinder. Take readings every 3°C, until the water temperature has cooled to 50°C. Then add ice to the beaker to lower the temperature below 3°C. Record the volume of the air bubble at low temperature. Also record the value of the barometric pressure.

Use the data obtained at low temperature to find the number of moles of air in your bubble. Then calculate the partial pressure of air at each of those temperatures. Prepare a table with columns for *t(°C), T(K), 1/T,* P_{H2O} and 1nP. Use your tabulated results to prepare a plot of 1nP versus $1/T$. Use your plot to find the value of ΔH_{vap} for water. Predict the normal boiling point of water.

Disposal of Reagents

The water and ice in this experiment can be discarded in the sink.

QUESTIONS

1. What is the uncertainty associated with each of your volume observations? How does this affect your value of P_{H2O} at 50°C?

2. You could Obtain ΔH_{vap} by inserting the data from two P_{H2O} measurements into Equation 13.4, or from a plot of data from 8-10 measurements, as in this experiment. Which procedure is better? Why?

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I. Title: Experiment 13, The Vapor Pressure of Water

II. Purpose: By using a simple apperatus, the relationship between the vapor pressure of water and temperature will be studied.

III. Procedure:

1) Obtain beaker large enough for 10 ml graduated cylinder to be submerged in it; fill 1/2 full with distilled water.
2) Fill graduated cylinder to 90% capacity with distilled water; place finger over mouth and invert in beaker.
3) A 4 to 5 ml air bubble should remain in cylinder.
4) Add distilled water until cylinder completely covered.
5) Heat water in beaker to 75 or 80°C; remove beaker from heat.
6) Record volume of air bubble and water temperature every 3°C until water temperature cools to 50°C.
7) Add ice to beaker to lower water temperature below 5°C; record volume of air bubble.
8) Record value of barometric pressure.

IV. Data: see attached Summary Report.

V. Results:

DATA OF WATER VAPOR

moles of air	1.64×10^{-4} moles
ΔH_{vap}	41500 J/mol
predicted normal boiling pt.	100.5°C

VI. Calculations:

moles of air = PV/RT

$\Delta H_{vap} = (-\text{slope})(R)$

$\ln P_2 - \ln P_1 = \Delta H_{vap}/R(T_2^{-1} - T_1^{-1})$ where T_1 is the predicted normal boiling pt.; convert to C

VII. Questions:

1) The percentage uncertainty would be higher at a lower temperature such as below 50°C because the volume of the air bubble would be more difficult to read and record accurately.

2) It is best to use the given equation in order to obtain a more accurate measurement. By using the plotted data, it is more difficult to predict what the actual value is, thereby, obtaining only a rough estimate of the change in vaporization enthalpy.

VIII. Conclusion:

A direct relationship between the effect of temperature and pressure on the volume of an air bubble can be determined. The pressure of air increases as the temperature and volume of the water decrease. With various vapor pressures, the normal boiling point of water and the enthalpy of vaporization can be determined.

SUMMARY REPORT ON EXPERIMENT THIRTEEN

Observations

Barometric Pressure 744.9 torr

t(°C)	V (mL)
75°	7.50 ml
72°	7.20 ml
69°	6.78 ml
66°	6.40 ml
63°	6.10 ml
60°	5.90 ml
57°	5.65 ml
54°	5.40 ml
51°	5.20 ml
5.0°	3.85 ml
4.5°	3.80 ml

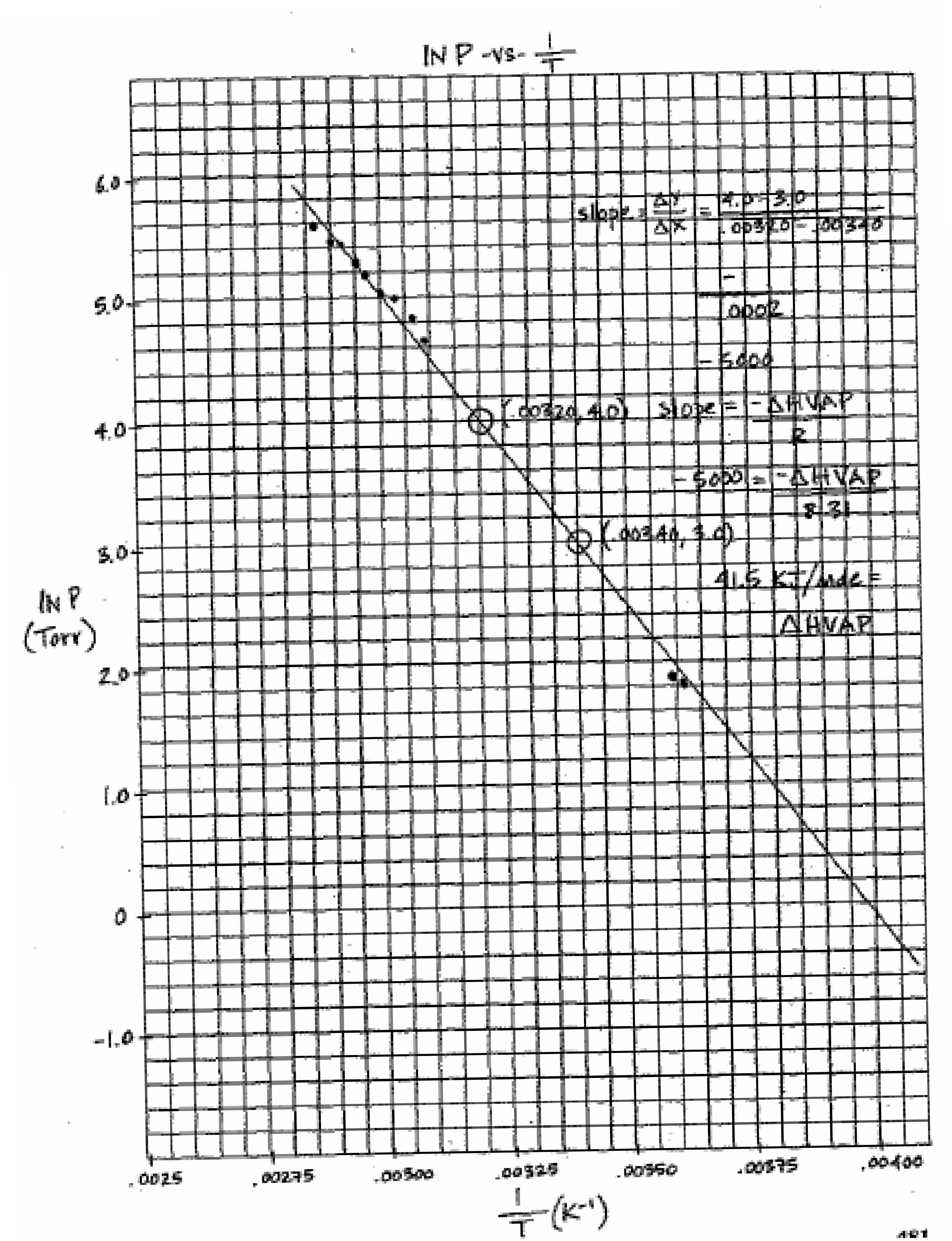
Tabulated Results

n_{air} 1.64×10^{-4} moles

t(°C)	T(K)	$1/T$(K^{-1})	P_{air}(torr)	P_{H_2O}(torr)	ln P
75° C	348 K	.002873	474.6	270.3	5.6
72° C	345 K	.002898	490.1	254.8	5.54
69° C	342 K	.002924	515.9	229.0	5.43
66° C	339 K	.002950	541.8	203.1	5.31
63° C	336 K	.002976	563.4	181.5	5.20
60° C	333 K	.003003	577.3	167.6	5.12
57° C	330 K	.003030	597.4	147.5	4.99
54° C	327 K	.003058	619.4	125.5	4.83
51° C	324 K	.003086	637.3	107.6	4.68
5.0° C	278 K	.003597	738.54	6.36	1.85
4.5° C	277.5 K	.003604	744.9	0	$-\infty$

ΔH_{vap} 41500 J/mol

Predicted normal boiling point of water 100.5 °C



ln P -vs- 1/T
slope = ΔY/ΔX = 4.0 − 3.0 / .00320 − .00340
= 1 / −.0002
= −5000
(.00320, 4.0)
slope = −ΔHVAP / R
−5000 = −ΔHVAP / 8.31
(.00340, 3.0)
41.5 KJ/mole = ΔHVAP
ln P (Torr)
6.0
5.0
4.0
3.0
2.0
1.0
0
−1.0
.0025
.00275
.00300
.00325
.00350
.00375
.00400
1/T (K⁻¹)