Work Sample & Commentary: *The Challenger Disaster*
High School Science

The task[207]

The task was in the form of an investigation in which students were asked to test the hypothesis that the unusually cold temperatures at the time of the Space Shuttle Challenger launch might have reduced the ability of O-Rings to expand and seal the Solid Fuel Booster Rocket Field Joints. Students designed and performed experiments in research teams. The students then prepared individual reports of their findings to the Challenger Commission as a homework assignment.

Circumstances of performance

This sample of student work was produced under the following conditions:

√ alone	in a group
in class	√ as homework
√ with teacher feedback	with peer feedback
timed	√ opportunity for revision

This work sample illustrates a standard-setting performance for the following parts of the standards:[208]

S1b Physical Sciences Concepts: Structure and properties of matter.

S1d Physical Sciences Concepts: Motion and forces.

S4a Scientific Connections and Applications: Big ideas and unifying concepts.

S5a Scientific Thinking: Identify and control variables.

S5e Scientific Thinking: Identify problems.

S5f Scientific Thinking: Work individually and in teams.

S6c Scientific Tools and Technologies: Collect and analyze data.

S7a Scientific Communication: Represent data in multiple ways.

S7b Scientific Communication: Argue from evidence.

S7e Scientific Communication: Communicate in a form suited to the purpose and the audience.

S8a Scientific Investigation: A controlled experiment.

What the work shows

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of structure and properties of matter....

(A) The student states that "...O-Rings when frozen or cold will react different. I feel they won't stretch properly..." indicating an understanding of how environmental conditions may affect the physical properties of materials.

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[207] For related work on Force and Motion, see "Come Back Can", page 60, and "Mechanical Nut", page 188.
[208] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 292-339.

S1d Physical Sciences Concepts: The student produces evidence that demonstrates understanding of motion and forces,....

(B) The student designed an experiment in which increasing force was applied to the rubber band. The student measured the change in length resulting from the increase in applied force.

S4a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as...cause and effect.

(A) The student links the temperature effects on rubber elasticity with the failure of the O-Rings to perform properly during the Challenger launch.

S5a Scientific Thinking: The student identifies and controls variables in experimental...research.

(B) The student altered the independent variable (marble mass) in a systematic manner and evaluated the dependent variable (rubber band length). "We then proceeded to add five marbles at a time. ...we measured the stretch of the rubber band."

(C) "The next day, we did the exact experiment with one change. The plastic bowl this time didn't have ice." This clearly indicates understanding of the importance of altering only one condition at a time.

S5e Scientific Thinking: The student identifies problems...evaluates the accuracy, design, and outcomes of investigations.

(D) The student raises the duration of exposure to freezing temperatures as a possible variable, and suggests extending the exposure time to determine if this has a significant effect on elasticity.

S5f Scientific Thinking: The student works individually and in teams to collect and share information and ideas.

(E) The student indicates in the Procedure section that experiments were designed and performed as a team, but the data analysis, graphing and report writing were done individually.

S6c Scientific Tools and Technologies: The student collects and analyzes data....

(F) The student indicates that experiments were repeated three times, and the results averaged to obtain a more precise measurement.

(G) The student calculated a percent change in length to analyze the experimental results.

S7a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables and graphs....

(H) The student presented the raw, averaged and percent change in length data in table forms.

(I) The student graphed the averaged data for the two experimental conditions (with and without ice).

(J) The student graphed the percent change in length data for the two experimental conditions.

(K) The student provided a drawing of the experimental setup to supplement her written description of the equipment used.

S7b Scientific Communication: The student argues from evidence....

(L) The student notes the change in elasticity as a result of cooling demonstrated by her data and argues that this is consistent with her hypothesis that the Challenger O-Rings were unable to perform properly on the day of the accident.

S7e Scientific Communication: The student demonstrates effective scientific communication, that is the student communicates in a form suited to the purpose and the audience....

The student work contains Introduction, Materials, Procedure, Results, and Discussion sections, typical of a formal scientific report. This is appropriate to the assigned task of reporting results to a Presidential Commission.

S8a Scientific Investigation: The student demonstrates scientific competence by completing a controlled experiment.

(C) The experiment described in this procedure is properly designed to evaluate the effect of temperature on elasticity. The same procedure was used for experiments at room and ice temperatures.

The Challenger Disaster

Introduction

The space shuttle Challenger exploded and was destroyed during its launch killing all aboard. Many factors contributed to this disaster. One engineer tried to delay the launch. He believed the temperature had been too cold overnight. There was frost on the ground and on the shuttle earlier in the morning. The project managers were not convinced that the risk overshadowed the economic and public relations costs of delaying the launch.

Everything went on as planned and they launched the rocket. A few seconds later, the color of the flame changed. The main hydrogen tank had ruptured. The hydrogen was now fueling in the flame. This intense flame caused the strut to completely separate. The booster could now pivot freely. The aft dome of the hydrogen tank failed and dropped away. The remaining hydrogen was suddenly released producing a thrust that drove the remains of the hydrogen tank into the oxygen tank. At the same time the solid booster swung around and collided with the bottom of the oxygen tank rupturing it and releasing the contained gas. The explosion that followed was massive.

A My prediction about the outcome of our experiment is that the O-rings when frozen or cold will react different. I feel they won't stretch properly and may of caused this Challenger disaster.

Materials

Rubber bands (3)	String (1 ft)
Container (with ice)	Plastic cup
Paper clips	Ruler
Marbles (30)	

E Procedures

The materials above is what we used for our experiment. What we did was punch two holes on the side of the cup (opposite each side). Then we inserted a paper clip in each hole. We connected each paper clip on both side to make a handle. The third paper clip was taped on the top side of the container. We then attached the rubber band to the paper clip and tied the string around the rubber band. With the other end of the string we tied it to the paper clip that were on the cup. So now the cup is hanging from the container.

B We then proceeded to add five marbles to the cup at a time.. Each time we dropped five marbles into the cup we measured the length of the rubber band. We did this six times, because we had thirty marbles. We did the whole experiment three times to see if there was any difference any time. After this we averaged out measurements and got a precise average. We also calculated the % change in length since the rubber bands started at different lengths. F

The next day we did the same exact experiment with one change. The plastic bowl this time didn't C have ice. We did this to see if there was a difference in the measurements which would allow us to predict what went wrong on the Challenger.

G Then I graphed our length and % change in length data.

Discussion

L As you can see in our report and data charts there was a slight change in measurements between the experiment with the ice and the experiment without ice. The experiment with ice, the rubber band stretched less. So I'm figuring that on the space shuttle Challenger disaster, the O-rings might of stretched less than usual and might of caused this disaster.

D Another way to investigate this problem is leaving the rubberband over night over the bowl of ice. Since the Challenger in the morning was found frozen, so this could of happened in the night. In our experiment we didn't leave the rubber bands long enough on the ice to see if there's a real big difference. If we do this there might be a greater change in our measurements.

This project on the Challenger Disaster was a great learning experience and it was fun while I learned. The challenger disaster was a horrible accident that maybe can be avoided. I'm thankful my classmates and I can be helpful.

H **TABLE 1. Rubber Band Stretch Without Ice**

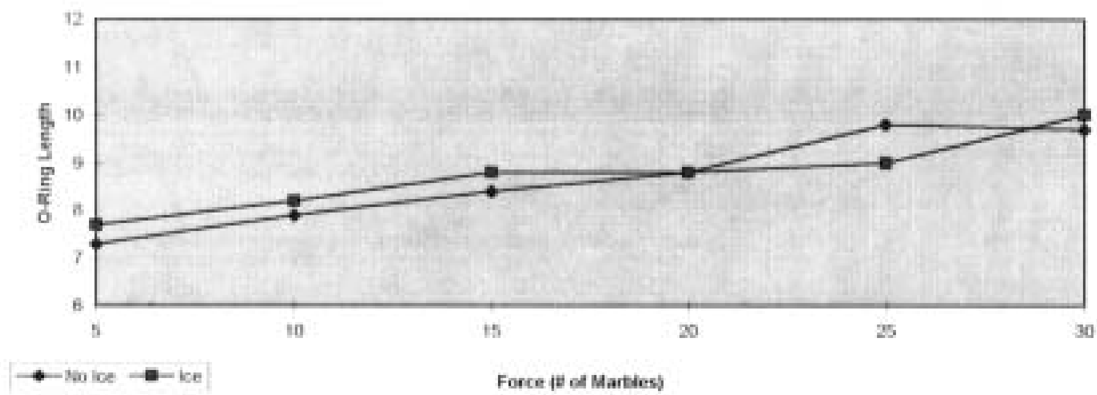
# of Marbles	First Test	Second Test	Third Test	Average	Percent Change
5	7.2 cm	7.4 cm	7.4 cm	7.3 cm	0%
10	8.0	7.8	7.8	7.9	8
15	8.5	8.2	8.4	8.4	15
20	8.8	8.5	9.0	8.8	21
25	9.8	9.0	9.3	9.4	27
30	10.0	9.5	9.6	9.7	33

TABLE 2. Rubber Band Stretch With Ice

# of Marbles	First Test	Second Test	Third Test	Average	Percent Change
5	7.5 cm	7.5 cm	8.0 cm	7.7 cm	0%
10	8.5	8.0	8.0	8.2	6.5
15	9.0	9.0	8.5	8.8	14
20	9.0	9.0	8.5	8.8	14
25	9.0	9.0	9.0	9.0	17
30	10.5	9.5	10.0	10.0	30

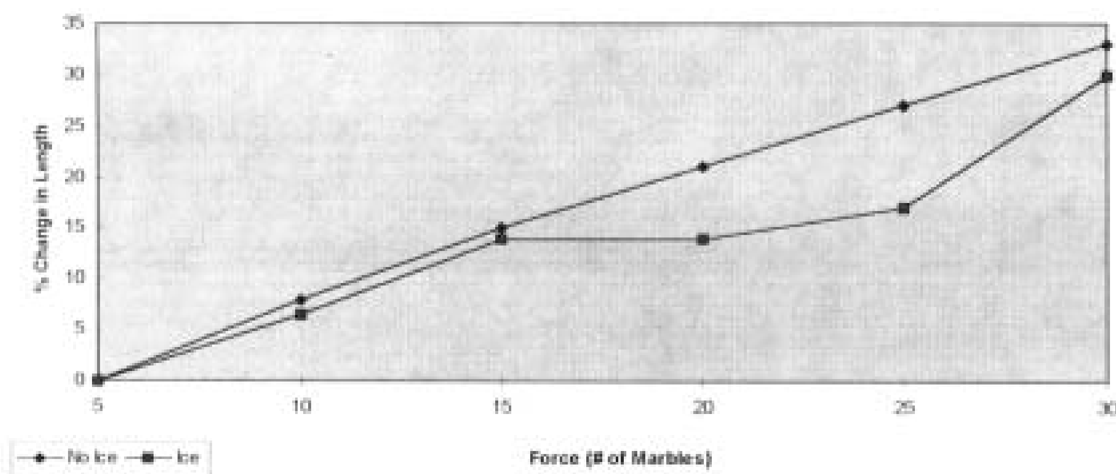
I **FIGURE 1**

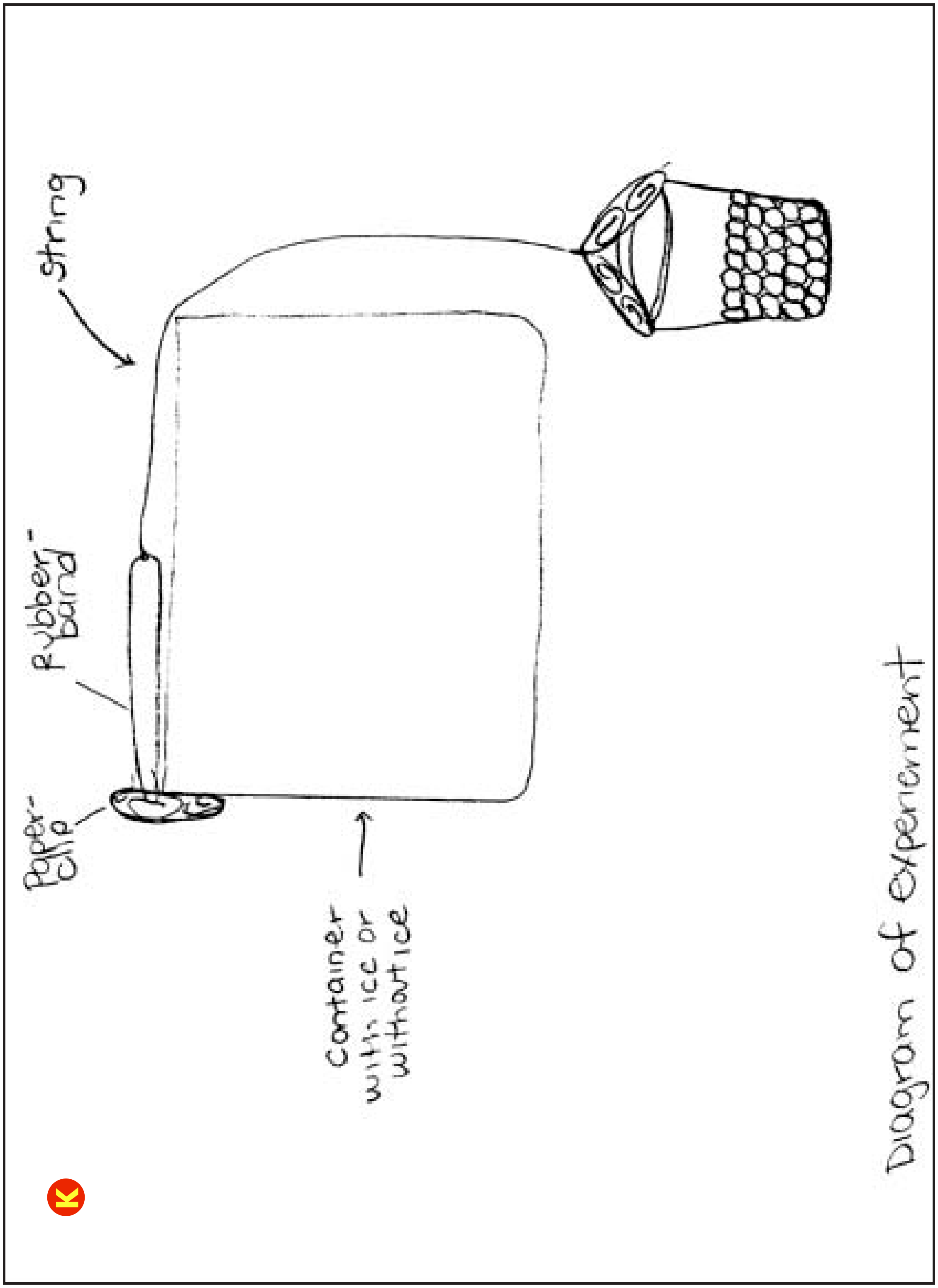
Change in O-Ring Length at Different Temperatures



J **FIGURE 2**

% Change of O-Ring Length at Different Temperatures




String
Rubber-band
Paper-clip
Container with ice or without ice
Diagram of experiment

The task[209]

Students in a high school environmental science class were asked to compare an unbuffered solution with a buffered solution by using the technique of titration. This assignment was one of the lab activities in a unit on acid rain.

Circumstances of performance

This sample of student work was produced under the following conditions:

	alone	√	in a group
√	in class	√	as homework
	with teacher feedback		with peer feedback
	timed		opportunity for revision

This work sample illustrates a standard-setting performance for the following parts of the standards:[210]

S1c Physical Sciences Concepts: Chemical reactions.

S4a Scientific Connections and Applications: Big ideas and unifying concepts.

S4b Scientific Connections and Applications: The designed world.

S5a Scientific Thinking: Frame questions to distinguish cause and effect; identify or control variables in experimental or non-experimental research settings.

S5b Scientific Thinking: Use concepts from Science Standards 1–4.

S6a Scientific Tools and Technologies: Use technologies and tools.

S7a Scientific Communication: Represent data and results in multiple ways.

S7b Scientific Communication: Use facts to support conclusions.

What the work shows

S1c Physical Sciences Concepts: The student produces evidence that demonstrates understanding of chemical reactions, such as everyday examples of chemical reactions.

(A) (B) The student expresses understanding of the nature of chemical reactions in the concise explanations of the effects of buffers on ions.

(A) The student's explanation of why calcium carbonate is not a good buffer demonstrates an understanding of the role of ionic dissociation in a subsequent chemical reaction.

[209] For related work on Acids and Bases, see "Acid/Base", page 70, and "Acid Rain", page 198.

[210] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 292-339.

S4a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as...cause and effect.

(B) The student explicitly states that increasing the proportion of Na_2HPO_4 (sodium phosphate) in relation to the acid will result in the release of more ions.

Throughout the answer to question 1 and especially at (D), the student expresses the results of the investigation as causal relationships.

(E) In the answer to question 2, the student clearly states the chemical cause behind the sudden change in the pH data.

S4b Scientific Connections and Applications: The student produces evidence that demonstrates understanding of the designed world, such as the reasonableness of technological designs.

(F) Throughout the answer to question 6, the student logically and correctly identifies scientific limitations to the use of lime in neutralizing an acidic lake. The student's statements are actually conclusions based on the outcome of the investigation.

(G) At the end of the answer to question 6, the student describes a fundamental societal limitation—economic—on large-scale use of lime to neutralize an acidic lake.

S5a Scientific Thinking: The student...identifies variables in experimental and non-experimental research settings.

(B) The student correctly identifies the proportion of Na_2HPO_4 as the variable that determines its capacity to absorb acid.

(H) The student correctly identifies the addition of lime as a variable that will increase pH, and states that the addition of other acids—another variable—will lower the pH.

(I) The student notes the simultaneous effects of two variables in this statement.

S5b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

(J) The student uses understanding of S1c, specifically ionization and buffering, to explain the phenomena observed.

(K) The student applies understanding of S1c to a new situation in the suggestion that biological ("organic") inhabitants of a lake may excrete basic substances, and that introduction of such species into a damaged lake might provide natural buffering.

S6a Scientific Tools and Technologies: The student uses technology and tools...to observe and measure...with appropriate consideration of accuracy and precision.

(L) The student's collection of data demonstrates competence in using lab equipment (pH meter and equipment for titration) and the ability to observe and accurately measure phenomena. The student demonstrated appropriate consideration of accuracy and precision by recording consistent significant figures.

S7a Scientific Communication: The student represents data in multiple ways, such as tables and graphs...and selects the most effective way to convey the scientific information.

(L) (M) The student's data are expressed in both table and graph forms. The graph organizes data from the table so that a viewer can instantly compare the buffering abilities of sodium phosphate and water.

S7b Scientific Tools and Technologies: The student uses technology and tools…to observe and measure…with appropriate consideration of accuracy and precision.

(J) The answer to question #3 indicates the student's ability to argue from evidence. The decision that water is not a good buffer is based on data produced through experimentation.

Spelling errors present in this work do not detract from the quality of the science.

Following are the lab questions answered by the student:

1. Examine your graph for the titration of sodium phosphate. Explain the shape of the three parts of the curve.
2. Explain why below pH 6 the curve drops off sharply.
3. Compare the titration curves obtained for water and for sodium phosphate. Explain the difference.
4. How could we increase the capacity of our sodium phosphate solution to absorb acid?
5. Calcium carbonate is not particularly soluble in water (very little of it will dissolve in water). What problem does this present.
6. "Lime" is actually calcium hydroxide [$Ca(OH)_2$]. Why is trying to neutralize an acidic lake using lime not a good idea?
7. Give a better strategy for neutralizing the waters of an acidic lake.
8. Predict the contents of commercial preparations used to increase the pH of fish tanks. Why is the method of increasing pH in the fish tank critical?

L

Buffer Lab

Data

pH titration with .02M Na_2HPO_4:

.1M HCl drops	pH
0	9.87
1	9.51
5	8.52
10	7.74
15	7.46
20	7.28
30	6.99
40	6.67
50	6.34
60	5.83
70	3.40
75	2.97
80	2.73
85	2.56
95	2.41
105	2.32
115	2.17
125	2.06

Formation of Phosphoric Acid

$$\boxed{3H^+ + PO_4^{3-} \rightarrow H_3PO_4}$$

pH titration with water (H_2O):

drops	pH
0	6.25
1	5.01
9	2.62
14	2.41
19	2.22
24	2.15
29	2.09
34	2.02

Lab Questions:

① The graph for the titration of sodium phosphate has four areas made up of two key features. As labeled on the graph, section ① is decreasing. This shows that the buffer is working on the ions to buffer them. **A** Section ② is level and is the optimum buffering range for this buffer. Section

D ③ is a steep decrease because the buffer can no longer support that amount of drops of acid. Finally, section ④ is level which shows that the buffer is working again.

E ② The reason that the curve drops off sharply below pH 6 is because the buffer is designed to keep the pH constant at a pH of 7. When the limit on the buffer (#of drops) is reached, it can no longer maintain the constant, and it plummets.

J ③ The curve for sodium phosphate and that for water are very different. The water appears to not be a decent buffer at all unless you want a pH of 1. The sodium phosphate on the other hand has a gradual [illegible] decent inters-persed with areas of obvious buffering.

④ To increase the capacity of our sodium phosphate solution to absorb acid simply **B** increase the proportion of Na_2HPO_4 to acid. This will make available more ions [illegible] to be released to [illegible] with the acids.

Buffer Lab

(5) Since the calcium carbonate doesn't dissolve in water, its ions cannot dissociate C in order to bond with acids. Therefore it is a poor buffer that will probably have little to no effect on the solution.

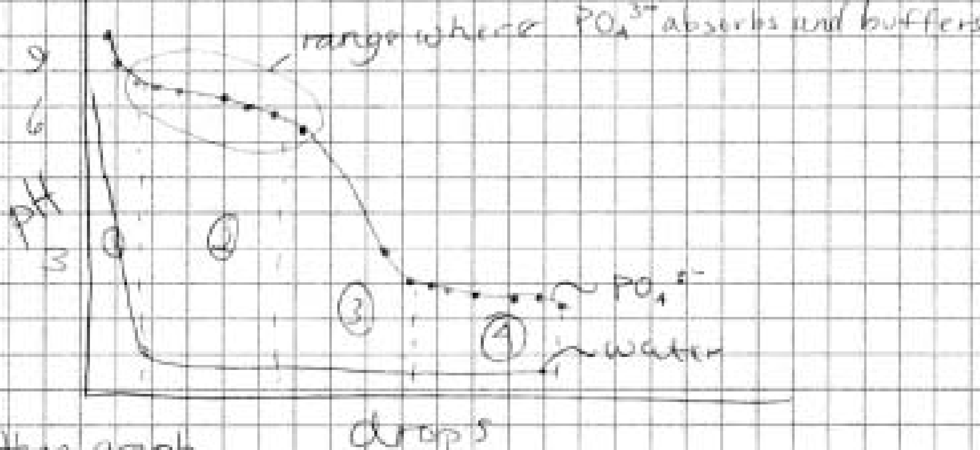
(6) There are several problems with using F lime to neutralize an acid lake. First, the pH adjustment of a lake is a very delicate matter. The addition of lime will cause H a large jump in the pH that will need to be lowered by the adding of other acids. Also, lime is a chalky, thick substance that will cloud the lake and possibly block out the sunlight. Finally, lime is G very expensive to have to keep using to fix a lake.

(7) With some investigation, one may find the existence of certain organic inhabitants of lake environments to live in the lake and K excrete basic substances. It could be a bird who's droppings are basic, or a plant that will add basicity when it decomposes, or even a bacteria. If one could be found and introduced, the problem could be solved naturally.

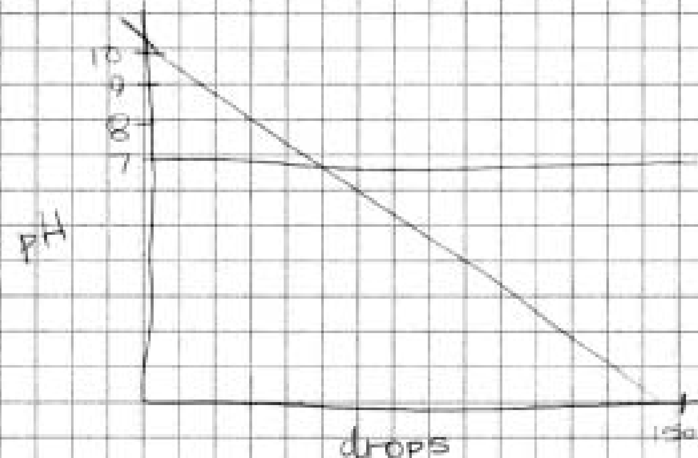
(8) The contents of commercial preparations used to increase the pH of fish tanks would have to consist of both bases and buffers. I The bases would work on increasing pH, and the buffers would hold it at a constant level. If the pH changes too rapidly, all the fish in your tank will die.

M

Sketches of Graphs



~~When graph~~
Between pH 6 and pH 3, sodium is very sensitive to change



Work Sample & Commentary: *Heating Curve of a Substance*
High School Science

The task

Students were asked to conduct a simple experiment in which they recorded temperature changes that accompany the melting and boiling of a pure substance. This assignment was given to students in a Science Research class.

Circumstances of performance

These samples of student work were produced under the following conditions:

√ alone	√ in a group
√ in class	√ as homework
with teacher feedback	with peer feedback
√ timed	opportunity for revision

These work samples illustrate standard-setting performances for the following parts of the standards:[211]

S1b Physical Sciences Concepts: Structure and properties of matter.

S1e Physical Sciences Concepts: Conservation of energy and increase in disorder.

S4a Scientific Connections and Applications: Big ideas and unifying concepts.

S5b Scientific Thinking: Use concepts from Science Standards 1–4.

S6a Scientific Tools and Technologies: Use technologies and tools.

S6e Scientific Tools and Technology: Recognize and limit sources of bias in data.

S7a Scientific Communication: Represent data and results in multiple ways.

What the work shows

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of structure and properties of matter, such as...characteristics of phase changes.

(A) The student describes the observed process in terms of phase change characteristics.

(B) (C) The student describes changes in temperature in terms of molecular interactions.

(D) The student's hypothesis clearly relates phase change and energy.

S1e Physical Sciences Concepts: The student produces evidence that demonstrates understanding of conservation of energy and increase in disorder, such as kinetic and potential energy...and effects of heat and pressure.

(A) (F) The student describes how a transfer of energy causes a phase change.

(D) The student describes the effects of heat in relative terms.

(E) The student demonstrates understanding of the relationship between kinetic energy, heat, and temperature.

[211] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 292-339.

S4a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as…cause and effect.

(C) (G) (H) The student demonstrates understanding of cause and effect relationships between change of temperature and change in state of matter.

S5b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

(I) The student uses the concept of phase change to explain constant temperature during the observation.

(J) The student compares the liquid and gaseous phases of water in terms of relative molecular organization and motion.

S6a Scientific Tools and Technology: The student uses technology and tools (such as traditional laboratory equipment…) to observe and measure…phenomena, directly…with appropriate considerations of accuracy and precision.

(K) (L) (M) The student uses various pieces of laboratory equipment to observe and measure the effects of heat.

S6e Scientific Tools and Technology: The student recognizes and limits sources of bias in data, such as observer and sample biases.

(N) The student indicates that calibration of the thermometer is needed in order to get an accurate temperature reading.

S7a Scientific Communication: The student represents data and results in multiple ways, such as numbers, tables and graphs; [and] technical…writing; and selects the most effective way to convey the scientific information.

(A) (B) (D) (F) (G) (H) These items and others indicate the student's ability to convey information through technical writing. It should be noted that errors in Sample 1 should be corrected in a revision. In item 2a, for example "liquid to gas" should be corrected to "solid to liquid." In item 4a, the water molecules are most definitely in motion at 100 degrees Celsius. The student's logic is correct in 4a, but the statement regarding molecular motion indicates a misconception that needs to be corrected.

(M) (O) The student records data in tables.

(P) (Q) The student uses a graph to represent the data recorded in the tables.

Sample 1

Bio-Science Research
Laboratory

Experimento: Temperatura y Cambios de Estados (Cambios de Fases)

Procedimiento:

L

1. Ponga un termómetro en un envase de 250 ml que contenga agua y hielo. Empieza a tomar el tiempo y observa el cambio de temperatura cada minuto mientras revuelva continuamente. Asegurese de anotar la temperatura del hielo solamante. Desarolle una tabla y ponga toda la información en su tabla de datos.

Tiempo (minutos)	Temperatura (Centigrados)
0 minuto	-7□ Centigrados
1 minuto	-5□ Centigrados
2 minutos	-3□ Centigrados
3 minutos	-2□ Centigrados
4 minutos	-1□ Centigrados
5 minutos	0□ Centigrados

F

a. Por qué es importante revolver constantemente?

Es importante mantener una ritmo constante cuando estamos revolviendo porque esto causa que la energía cinética del sistema incremente. Inevitablemente, esto causa la temperatura del sistema suba. Como la temperatura del hielo es baja, necesita mucho calor para que suba de temperatura y cambie C

Sample 1 (cont.)

de estado. La temperatura de un hielo completamente solido es de zero grados centigrados. Como las moléculas del hielo están tan juntas y sin casi moverse, se necesita más energia para que la temperatura cambie. La transferencia de energia a una temperatura constante de zero grados centigrados significa que el cube de hielo esta pasando por un cambio de fase. Despues que el hielo se haya derretido completamente su temperatura comienza a subir.

I

2. Continua observando y anota la temperatura en intervalos de un minuto por cinco minutos.

Tiempo (minutos)	Temperatura (Centigrados)
0 minuto	0□ Centigrados
1 minuto	0□ Centigrados
2 minutos	1□ Centigrados
3 minutos	3□ Centigrados
4 minutos	5□ Centigrados
5 minutos	6□ Centigrados

a. Describe los cambios de estado (fases) que ocurrieron.

Durante la temperatura constante de zero grados centigrados el cubo de hielo pasó por cambio de fase. La substancia cambió de sólido a liquido. Despues que ha cambiado completamente de liquido a gas, la temperatura comenzó a subir a un grado centigrado. La energia cinética aumenta la temperatura haciendo que el hielo pasara por los cambios de fases.

Sample 1 (cont.)

3. Ponga un envase en una hornilla y continue observando y anotando cada minuto.

Tiempo (minutos)	Temperatura (Centigrados)
0 minuto	8□ Centigrados
1 minuto	14□ Centigrados
2 minutos	31□ Centigrados
3 minutos	52□ Centigrados
4 minutos	71□ Centigrados
5 minutos	82□ Centigrados
6 minutos	90□ Centigrados
7 minutos	94□ Centigrados
8 minutos	96□ Centigrados

4. Continue midiendo la temperatura cada minuto hasta que comienze a hervir vigursamente.

Tiempo (minutos)	Temperatura (Centigrados)
0 minuto	100□ Centigrados
1 minuto	100□ Centigrados
2 minutos	100□ Centigrados
3 minutos	100□ Centigrados
4 minutos	102□ Centigrados
5 minutos	1 03□Centigrados

Sample 1 (cont.)

6 minutos 104□ Centigrados

a. Describe los cambios de estado (fases) que ocurrieron.

Durante la temperatura constante de cien grados centigrados la substancia paso por un cambio de fase. Esto es evidencia de energia potencial porque las moléculas no estan en movimiento. Despues de haber cambiado completemente a liquido la temperatura commenzo a subir 101 grados centigrados. Durante el incremento la energia es cinética.

5. Haz una gráfica usando la información de las tablas.

a. De acuerdo con la curva de calor, cual es el punto de fusion del hielo?

De acuerdo con la curva de calor que yo marqué, el punto de fusión del hielo es zero grados centigrados.

b. Que patrones observaste en la gr"afica?

El orden que yo observé en la curva de calor es que cuando el sólido está cambiando a liquido la temperatura se conserva constante a cero grados centigrados.Despues de que el hielo ha cambiado completamente a liquido la temperatura subió. Durante el cambio de fase la temperatura permanese constante. Después que todo el liquido se ha convertido a gas la temperatura subió.

G

c. Como justificas la forma de la curva de calor?

La forma de la curva de calor es causada por el cambio de temperatura y fase.

d. Como ha afectado el tiempo cada seccion de tu gráfica?

El tiempo ha afectado la curva de calor porque en algunas secciones tomo más tiempo para cambiar de fase. En la curva de calor tomó más tiempo que la gráfica cambiará a de liquido a gas que cambiará a sólido a liquido. Tomó más tiempo porque toma más cantidad de energia de calor para cambiar de liquido a gas.

Sample 1 (cont.)

CONCLUSIONES:

1. Si fueras a replicar este experimento con alcohol en vez de agua , que cambios sucederian?

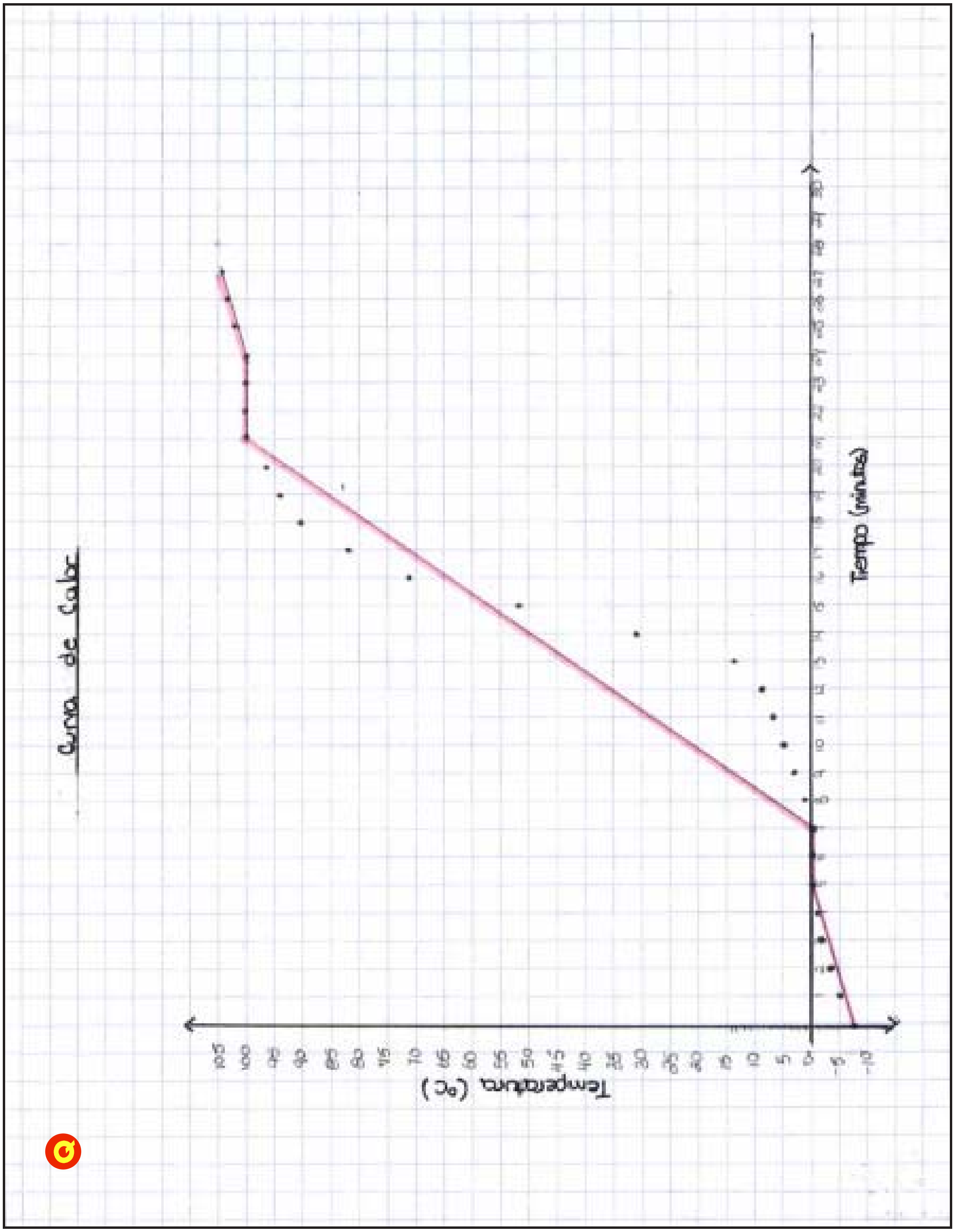
Si este experimento se duplicara pero en vez de agua fuera hecho con alcohol el punto de fusión y el punto de congelación seria diferente. El alcohol necesita menos energia de calor para evaporarse y derritirse.

D

2. Basandote en tus resulatdos de la curva de calor del agua, disena un experimento que justifique tu hipotesis

Comience el experimento colocando el termómetro en un envase de 250mL que debe contener un cubo de alcohol. Observe y apunte cada cambio de temperatura al mismo tiempo que esta revolviendo la substancia. Asegurase de mantener un ritmo constante cuando esta revolviendo el alcohol. Revolviendo el alcohol incrementa la temperatura del sistema y hace que el sistema cambie de fase más rápido. Acuerdese de apuntar la temperatura del cubo de alcohol solamente. Desarrolle una tabla de información y apunte el tiempo y la temperatura del alcohol hasta que el alcohol liege el punto de fusión que es-117 grados centigrados. Continue observando y apuntando la temperatura por cinco minutos. Ponga el envase en un plato caliente y continue observando y apuntando hasta que el alcohol llege a su punto de ebullición, que es 79 grados centigrados. Despues continue a observar la temperatura hasta que el sistema hierva vigorosamente. Cuando acaba el experimento, tome toda la informacion y muestrela gráficamente.

Sample 1 (cont.)



Sample 1 translation

Bio-Science Research
Laboratory

Experiment: Temperature and Change State (Phase Change)

Procedure: Answers

L

1. Place a thermometer into a 250mL beaker containing ice and water. Start timing and observing temperature change each minute while stirring continuously. Be sure to record the temperature of the ICE only. Develop a chart, and then record the time and temperature on a data table.

Time (minutes)	Temperature (Celsius)
0 min.	-7□ Celsius
1 min.	-5□ Celsius
2 min.	-3□ Celsius
3 min.	-2□ Celsius
4 min.	-1□ Celsius
5 min.	0□ Celsius

F

a. Why is it important to maintain a fairly constant rate of stirring?

It is important to keep a constant rate of stirring because this causes the Kinetic energy of the system to increase. Inevitability, this causes the temperature of the system to rise. Since the temperature of the ice is very low it needs a lot of heat and a rise in temperature to change in state. The temperature of a completely solid ice is always below zero degrees. Since the molecules of the ice are so tight C

Sample 1 translation (cont.)

together more energy is needed to melt the ice. More kinetic energy is needed and that is why the

I temperature changes. The transfer of energy and constant zero temperature means that the block of

Sample 1 translation (cont.)

CONCLUSIONS:

1. If you were to replicate this experiment with alcohol in place of water, what changes you happen?

HYPOTHESIS:

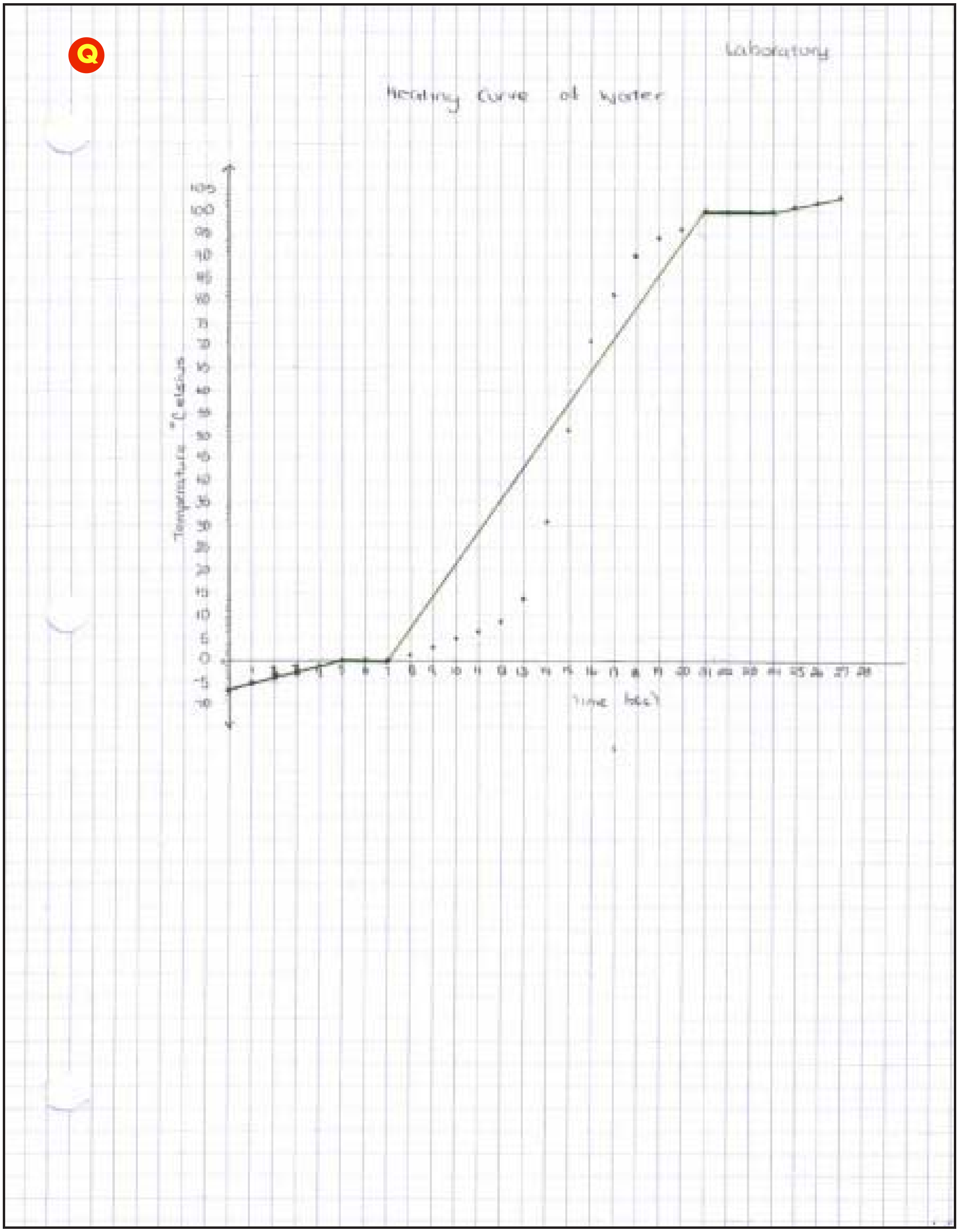
If this experiment were to be replicated but instead of water the experiment was done with alcohol the melting point and freezing point the experiment would be different. Also alcohol requires less heat energy to melt and evaporate than water..

D

2. Based on your data and results from Heating Curve of Water, design an experiment that will justify your hypothesis.

Place a thermometer into a 250ml beaker containing a solid block of alcohol. Start timing and observing temperature and speed up the phase changes. Be sure to record the temperature of the block of alcohol only. Develop a chart, and then record the temperature on a data table for the alcohol until the alcohol reaches it melting point of –117 degrees Celsius. Continue to observe and record the temperature at one-minute intervals for five minutes. Place the beaker on a hot plate and continue to observe and record at one- minute intervals until the alcohol reaches its boiling point of 79 degrees Celsius. Then continue to measure the temperature each minute until vigorous boiling occurs. After the experiment is completed graph the heating curve for alcohol.

Sample 1 translation (cont.)



Sample 2

Температура в каждую минуту

1) 0°C
2) 1°C
3) 0°C
4) 1°C
5) 0°C
6) 0.5°C
7) 0°C

таяние

Температура на горячей поверхности

1) 5°C
2) 10.5°C
3) 18°C
4) 31°C
15) 46°C
6) 56°C
7) 70°C
8) 80°C
9) 97°C
10) 101°C

жидкость

Температура испарения

1) 102°C
2) 102°C
3) 102°C
4) 102°C

кипение
жидкость и газ

Вопрос: Почему температура остается постоянной?
Ответ: Потомучто пока весь лёд не растает температура остается на уровне нуля.
Вопрос: Почему весь лёд одно-

Sample 2 (cont.)

временно не превращается в воду
во время таяния?
Ответ: Этого не происходит
потому что требуется дополни-
L тельные энергии для заверше-
ние процесса.
Вопрос: Энергия поглощается
или выделяется?
Ответ: Энергия поглощается
льдом.
Вопрос: Это процесс экзо или
эндотермический?
Ответ: Процесс этот эндотер-
мический потому что проис-
ходит поглощение энергии.
Вопрос: Почему необходимо теп-
ло для продолжения процесса?
Ответ: Тепло необходимо для про-
должение процесса в целях
полностью расстоинить лёд и
довести воду до кипение.
Вопрос: Почему температура
оставалась постоянной во вре-
мя процесса таяние, но за-
тем повысилась когда весь
лед превратился в жидкость?
A Ответ: Это происходит потому
что достигнув жидкой стадии
лед не находился более в точке
замерзания. Он перешел в сос-
тояние жидкости. Повышая тем-
пературу частицам мы увеличиваем кине-
E тическое движение что приводило

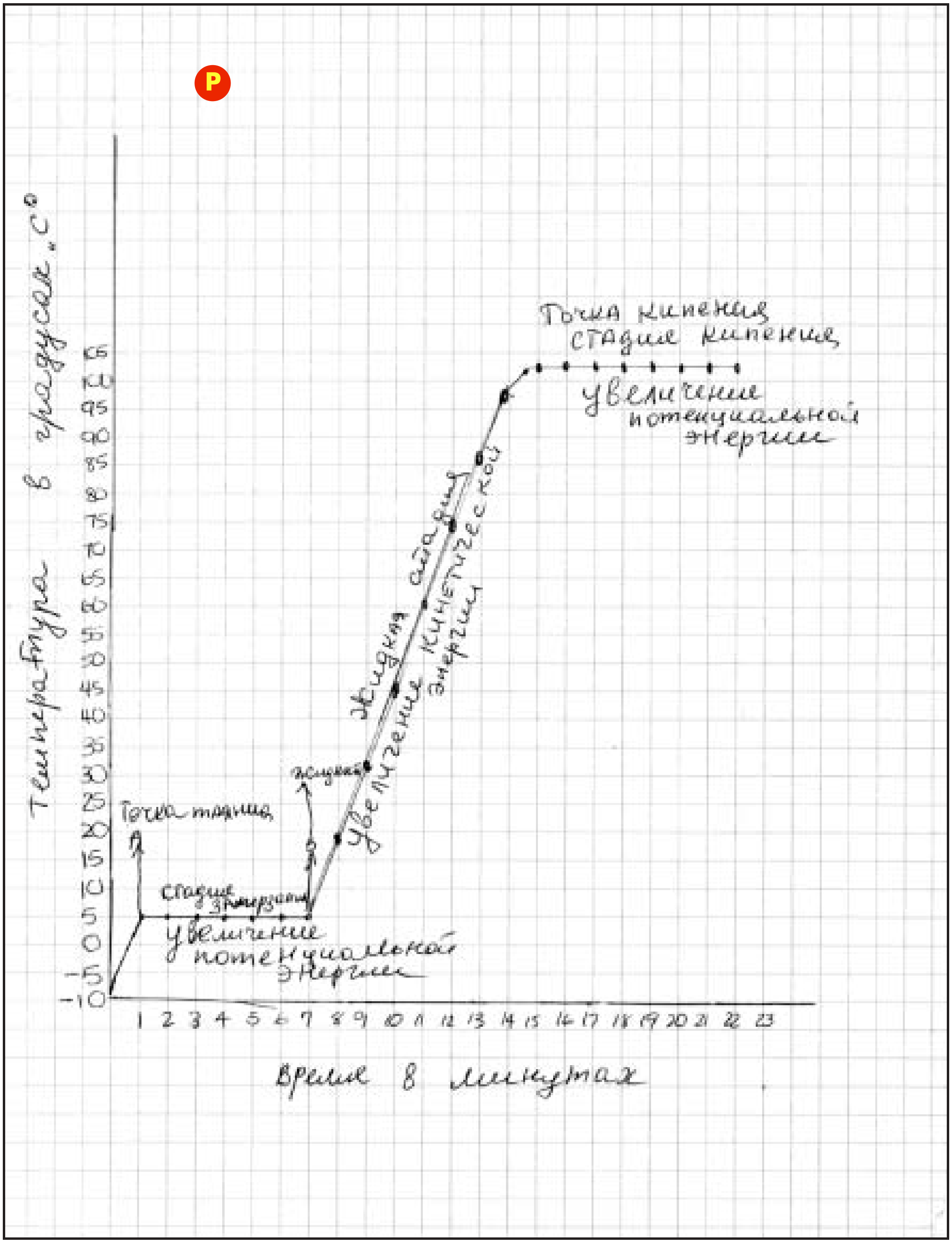
Sample 2 (cont.)

к повышению температуры
жидкости.
Вопрос: Сравните молекуляр-
ные силы льда и воды.
B Ответ: Молекулы льда (замерзшей
воды) плотно прилегают друг
к другу и почти не двигаются.
В молекулах „жидкой" воды боль-
шие расстояние между собой
что приводит к большей воз-
можности движения, т.е к
увеличению кинетической энергии

Вопрос Сравните молекулярные
силы в жидкости и газах.
J Ответ в сравнении с водой в парах
жидкости между молекулами
большое расстояние, что поз-
воляет им свободно двигаться
в разных направлениях.

— Объяснение допущеной ошибки —
Причина того что темпе-
ратура кипения в данном
опыте не зафиксирована 102°C, а замер-
N зание 1°C была в неточности
показаний моего термометра.
K Я это обнаружила путем
сравнения температур ки-
пения воды в колбе моим
термометром — 102°C А мое-
го соседа в той же колбе — 100°C!

Sample 2 (cont.)



Sample 2 translation

Temp every one minute
0°C
1°C
0°C
1°C
0°C
.5°C
0°C
melting

Temp on hot plate
1) 8°C
2) 10.5°C
3) 18°C
4) 31°C
5) 46°C
6) 56°C
7) 70°C
8) 80°C
9) 97°C
10) 101°C
Liquid

Vapor Temp =
1) 102°C
2) 102°C
3) 102°C
4) 102°C
Boiling
Liquid & Gas

Q: why does the temperature remain constant?
A: The temperature remains constant because until the ice completely melts it's at it's freezing point
Q: Why doesn't all of the ice change instantaneously during the melting process?
It doesn't change instantaneously because

Sample 2 translation (cont.)

H you have to keep adding ~~water~~ energy
in order for the ice to melt.
Q. Is energy absorbed or released?
A Energy is absorbed by the ice.
Q: Is this an endothermic or exothermic
process?
A. This process is endothermic because
energy is absorbed.
Q. Why was heat needed for the
continuation of the process.
A. Heat was needed to continue the
process because in order for ice to
completely melt and water to reach
it's boiling point you needed more
energy than just stirring the ice.
Q: Why did the temperature remain
constant during melting, but increases
when all ice has changed to liquid water?
A A: This occured because as all the ice
melted it was no longer at the freezing
point. It was at the liquid phase,
thus, trying to reach the boiling
E point. So an increase in heat = an
increase in kenetic energy = increase
in temperature.
Q: Compare intermolecular forces of solid
and liquid water.
B A. The molecules in solid water are
tightly packed, and barely moving.
The molecules in a liquid are less
tightly packed and have a rolling motion
(increase in KE)
Q. " " " " " liquid water and gaseous water

Sample 2 translation (cont.)

J A: Compared to liquid water gaseous water molecules are the least tightly packed and ~~[illegible]~~ move in differnt direction.

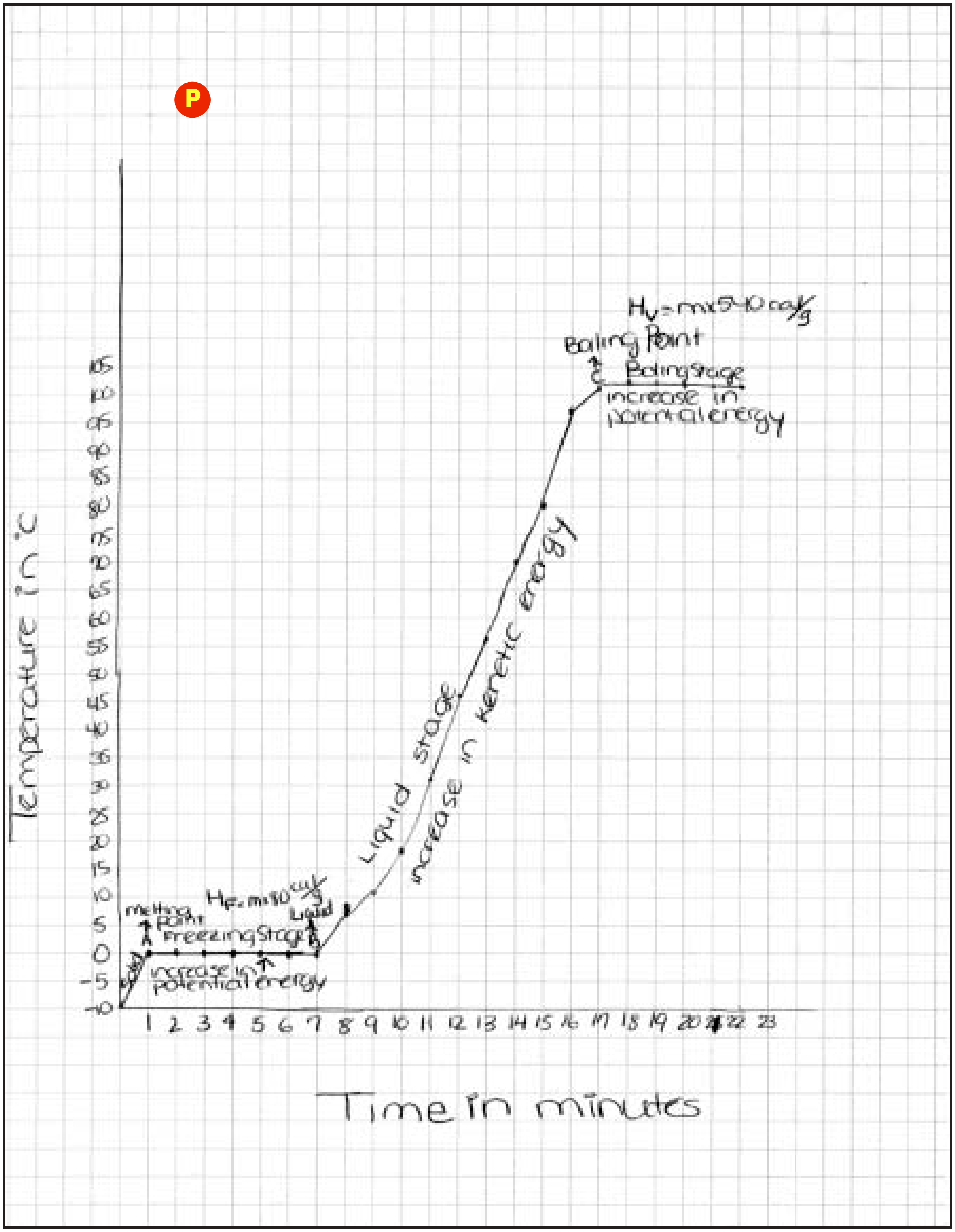
- Explanation for error -

The reason that my boiling point is 102°C and my freezing point is

N 1°C is because the thermoter was off. The way I found this out is by

K placing my thermometer into my partner's beaker. While his thermometer read 100°C (boiling point) my thermometer still read 102°C!

Sample 2 translation (cont.)



Work Sample & Commentary: *Exothermic/Endothermic Reactions*
High School Science

The task

This experiment was a modification of an experiment in the text *Chemistry: Visualizing Matter* (Holt, Rhinehart & Winston). In this activity, students were asked to design an experiment to prove whether a worker's claim that he was burned by a mixture two cleaning fluids was true. This assignment was given to a Regent chemistry class.

Circumstances of performance

This sample of student work was produced under the following conditions:

√ alone	√ in a group
√ in class	√ as homework
√ with teacher feedback	with peer feedback
√ timed	√ opportunity for revision

This work sample illustrates a standard-setting performance for the following parts of the standards:[212]

S1c Physical Sciences Concepts: Chemical reactions.

S4a Scientific Connections and Applications: Big ideas and unifying concepts.

S5a Scientific Thinking: Frame questions to distinguish cause and effect; identify and control variables.

S5b Scientific Thinking: Use concepts from Science Standards 1–4.

S6a Scientific Tools and Technologies: Use technologies and tools.

S7a Scientific Communication: Represent data and results in multiple ways.

What the work shows

S1c Physical Sciences Concepts: The student produces evidence that demonstrates an understanding of chemical reactions such as every day examples of chemical reactions....

(A) In the statement of purpose the student states that the reaction between sodium hydroxide(NaOH) and hydrochloric acid(HCl) involved heat change.

(B) This understanding is also expressed in the hypothesis, which states that the mixture will produce sufficient heat to cause a burn.

S4a Scientific Connections and Applications: The student produces evidence that demonstrates understanding of big ideas and unifying concepts, such as...cause and effect.

(C) The question clearly indicates that the student is looking for a cause and effect relationship.

(D) The student determined that the mixture could cause a burn because of the heat generated during the reaction.

(E) The student states that the concentration of sodium hydroxide remaining unreacted was too small to cause a chemical burn.

[212] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 292-339.

S5a Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies and controls variables in experimental and non-experimental research settings.

(C) The student frames the question appropriately.

(F) A review of the formulae in the "Analysis and Interpretation of Results" makes it very clear that the student identified and controlled variables, both in the experiment itself and in the follow-up analysis.

S5b Scientific Thinking: The student uses concepts from Science Standards 1 to 4 to explain a variety of observations and phenomena.

(F) Throughout the "Analysis and Interpretation of Results" the student uses physical science concepts from S1c expressed as formulae.

(G) The student expresses concepts from S1c in the "Related Background Information" section, and used them to develop the hypothesis.

S6a Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment...) to observe and measure objects...and phenomena, directly, indirectly, and remotely, with appropriate consideration of accuracy and precision.

(H) (I) The materials list and the "Experimental Procedure" section make it clear that the student used a graduated cylinder, a calorimeter, and a Celsius thermometer.

S7a Scientific Communication: The student represents data and results in multiple ways, such as numbers [and] tables...and selects the most effective way to convey scientific information.

(F) Throughout the "Analysis and Interpretation of Results" section, the student conveys scientific information through the use of formulae.

(J) (K) The student records data in a table format.

Chemistry
1/20/99

The purpose of this experiment is to determine the heat of the reaction between Hydrochloric Acid, and Sodium Hydroxide.

A

I will also determine the maximum temperature attained by mixing the two substances, and use the information to answer the main question: Does the mixture produce a sufficient amount of heat to cause a burn?

B

Hypothesis:

The mixture will produce sufficient heat to cause a burn. When some chemicals are mixed they are more dangerous because, they release large amounts of heat.

G

Related Background Information:

- All chemical changes involve energy. The energy change that takes place during a chemical change, generally are more noticeable than those taking place during a physical change.
- In some chemical reactions the products have less potential energy than the reactants. This occurs because, as the reactions proceeds the potential energy of the reaction decreases. This decrease occurs because some of the potential energy is converted (changed) to heat energy. This release of heat energy causes the substances to become hot.
- Chemical reactions that release heat energy are called exothermic. The reverse of this process would be an endothermic reaction.

Page 1

Methods & Data Procedure

H

Materials:
2 grams of sodium hydroxide pellets
0.50 M of hydrochloric acid (100mL)
graduated cylinder
calorimeter
Celsius thermometer
stirring rod
gloves
goggles
spatula
watch glass

I

Experimental Procedure:

Step 1 - I measured 100 mL or 0.50 M of HCl in a graduated cylinder. I poured the HCl in a Styrofoam cup in the calorimeter. Next, I recorded the temperature of the HCl solution to the nearest 0.1 °C

Step 2 - I measured the mass of a small dry beaker, and recorded it in my data table. Then I placed the pellets of sodium hydroxide in the beaker, and measured the mass of the sodium hydroxide (this was done quickly to prevent the absorption of moisture by the pellets).

Step 3 - I added the sodium hydroxide to the hydrochloric acid in the Styrofoam cup. I stirred the mixture and covered the lid of the calorimeter. Next, I measured, and recorded the highest temperature in the data table.

Results:

J

Data Table 1

Initial temperature of HCl	Final Temperature of HCl	Temperature Change
20 °C	32°C	12°C

Page 2

Data Table 2

K

Mass of empty beaker	22.5 grams
Mass of beaker & NaOH	24.5 grams
Mass of NaOH	2.0 grams

F

Analysis and Interpretation of Results:

1- Equation in the reaction:

$HCl_{(aq)} + NaOH_{(s)}$ --- $NaCl_{(aq)} + H_2O_{(l)}$

2- Calculations:

Objective 1- To determine the heat released by the reaction, by using the Formula.

$$\text{Heat} = m \times \Delta t \times C_{p,H_2O}$$

m = mass of water
Δt = temperature change
C_{P,H_2O} = specific heat capacity of H_2O

Δt = 12 °C
C_{P,H_2O} = 4.180 J/g °C
m = 100 grams

$$\text{Heat} = 100\cancel{g} \times 12\,°\cancel{C} \times 4.180\ \frac{J}{\cancel{g}\cdot°\cancel{C}}$$

= 5021 Joules
= 5.021 K. Joules

Objective 2 - To calculate the number of moles of NaOH in the solution used in the reaction.

Page 3

40 grams of NaOH = 1 mole of NaOH

2.0 grams of NaOH = 1 mole of NaOH x $\frac{2 \cancel{\text{grams of NaOH}}}{40 \cancel{\text{grams of NaOH}}}$

= 0.05 mole of NaOH
= 5×10^{-2} mole NaOH

Objective 3- To determine the amount of heat produced by the 1 mole of NaOH:

Since 5.0×10^{-2} moles of NaOH produced 5.02/ KJ
1 mole Of NaOH produced $\frac{-5.02 \text{ KJ} \times 1 \cancel{\text{mole of NaOH}}}{5.0 \times 10^{-2} \cancel{\text{mole of NaOH}}}$

= -101 KJ/mole

* Since the reaction is exothermic, the change in energy has a negative sign.

1- <u>What I know about the drain cleaner</u>.

(A) The labeled drain cleaner was estimated to contain 55 grams of NaOH in the drain cleaner, and 450 mL of solution containing a total of 1.35 moles of HCl.

<u>What I know about burns</u>.

(A) Third degree burns can occur if the skin comes in contact for more than 4 seconds with water that is hotter than 60 °C (140 °F).

Page 4

3- <u>What I want to know.</u>

C (A) Could the mixture of NaOH and HCl produce enough heat to cause burns?

To answer this question, I need to find out how much heat was released when 55 grams of NaOH react with HCl.

Number of moles of NaOH in the cleaner

$$= \frac{55\ \cancel{\text{grams}}}{\text{of}\ \cancel{\text{NaOH}}} \times \frac{1\ \text{mole of NaOH}}{40\ \cancel{\text{grams}}\ \cancel{\text{of}}\ \cancel{\text{NaOH}}}$$

= 1.375 moles of NaOH in the mixture.

Amount of heat produced when 1.375 moles react with HCl:

$$\Delta H = \frac{1.375\ \cancel{\text{moles}}}{\text{of}\ \cancel{\text{NaOH}}} \times \frac{101\ \text{KJ}}{1\ \cancel{\text{mole}}\ \cancel{\text{of}}\ \cancel{\text{NaOH}}}$$

= 139 KJ.

Next I need to find out the temperature change resulting from the reaction. By using the formula:

$$\text{Heat} = \text{mass of water} \times \Delta t_{H_2O} \times C_{P,\,H_2O}$$

$$\Delta t_{H_2O} = \frac{139\,000\ \cancel{\text{Joules}}}{450\ \cancel{\text{grams}}\ \text{of}\ H_2O} \times \frac{1\ \cancel{\text{g}}\cdot{}^\circ\text{C}}{4.184\ \cancel{\text{Joules}}}$$

$$\Delta t_{H_2O} = 73.8\ {}^\circ\text{C}$$

Final temperature of the mixture = 25 °C + 74 °C
= 99 °C

Page 5

3- <u>What I learned</u>.

D (A) The mixture was likely to cause a burn because 99 °C is much higher than 60 °C, which is the temperature at which a third degree burn is likely to occur.

E (B) The burn was not likely to be caused by direct contact with the chemical, since 1.35 moles of the HCl solution was neutralized by the 1.35 moles of the NaOH solution. Only 0.025 moles of NaOH remained unreacted, an amount too small in concentration to cause a chemical burn.

(C) Chemicals can be harmful if their special storage needs are ignored.

(D) Glass is heat sensitive, and will shatter if there is a sudden change in temperature, due to a chemical reaction.

<u>Discussion:</u>

Sources of Error:

(A) The metal stirring rod could have caused an increase in the heat of the reaction. A glass stirring rod would have been better.

(B) Some of the NaOH pellets started to absorb moisture before I added them to the HCl.

(C) Heat could have been lost during the time of adding the $NaOH_{(s)}$ to the $HCl_{(aq)}$.

(D) The drain cleaner was in liquid form but in our last experiment we used the actual NaOH pellets.

Page 6

Work Sample & Commentary: *Density of Sand*
High School Science

The task[213]

Sample 1 was an entry in a Golden State Examination Science Portfolio for the category "problem solving investigation." Students were required to submit a piece of work and the "Self-Reflection Sheet." In this case, the student designed and conducted an investigation to determine the density of sand. Sample 2 was done in class as a regular lab.

Circumstances of performance

These samples of student work were produced under the following conditions:

alone	√ in a group
√ in class	as homework
√ with teacher feedback	√ with peer feedback
timed	√ opportunity for revision

These work samples illustrate standard-setting performances for the following parts of the standards: [214]

S1b Physical Sciences Concepts: Structure and properties of matter.

S5a Scientific Thinking: Frame questions to distinguish cause and effect; and identify or control variables.

S5e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.

S5f Scientific Thinking: Work individually and in teams.

S6a Scientific Tools and Technologies: Use technology and tools.

S7e Scientific Communication: Write instructions that others can follow.

What the work shows

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of the structure and properties of matter....

(A) (B) (C) Throughout the work, the student explained the relationship between mass, volume, and density, often with a level of detail revealing excellent conceptual understanding. There is also ample evidence that the student appreciated the relevance of density in everyday situations.

S5a Scientific Thinking: The student frames questions to distinguish cause and effect; and identifies or controls variables in experimental and non-experimental research settings.

(D) Here and throughout, the work displays evidence of appropriate scientific thinking and use of experimental data to reach conclusions.

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[213] For related work on Density, see "Flinkers", page 76, "Discovering Density", page 209, and "Density", page 423.
[214] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 292-339.

S5e Scientific Thinking: The student identifies problems; proposes and implements solutions; and evaluates the accuracy, design, and outcomes of investigations.

(E) (F) (G) The student continually evaluated and critiqued the appropriateness of the experimental design and the accuracy of the measuring process, and described the situations in which the techniques employed would be most effective.

S5f Scientific Thinking: The student works individually and in teams to collect and share information.

(E) Comparison of results among groups provided partial confirmation of results.

(H) The student has acknowledged the benefits of collaboration.

S6a Scientific Tools and Technologies: The student uses technology and tools (such as traditional laboratory equipment…) to…measure objects directly, indirectly…, and with appropriate consideration of accuracy and precision.

(I) (J) The student used traditional methods.

(E) Comparison of results among groups was an effective method for judging accuracy.

S7e Scientific Communication: The student communicates in a form suited to the purpose and the audience, such as by writing instructions that others can follow….

(K)

Sample 1

The Density of Sand

Purpose: To determine the density of a sample of sand with air around the sand granules and then the density of the sand alone.

Procedure:

K

Find mass of sand + cup — Record

Find mass of empty cup — Record

Subtract the mass of the empty cup from the mass of the sand + the cup. The result is the mass of the sand. — Record

Put sand in a graduated cylinder, note volume. — Record

Remove sand, put 20 mL water in graduated cylinder.

Add sand to water, note volume of sand + water — Record

Subtract the volume of the water (20 mL) from the volume of the water + the sand. The result is the volume of the sand. — Record

Data:

Mass of sand + cup (g)	Mass of cup (g)	Mass of sand (g)
17.30	1.85	15.45

Volume of water + sand(mL)	Volume of water(mL)	Volume of sand (w/o air)mL
26.0	20.0	6.0

Volume of with air: 10.4 mL

Density with air: $\frac{M}{V}$ $\frac{15.45\text{ g}}{10.4\text{ mL}}$ = 1.49 g/mL

Density without air: $\frac{M}{V}$ $\frac{15.45\text{ g}}{6.0\text{ mL}}$ = 2.6 g/mL

Sample 1 (cont.)

Calculations and Analysis:

I 1. This lab was conducted using sand sample A. The mass of the sand was found by finding the mass of the sand in the cup, and then subtracting the mass of the cup. The mass of the sand was 15.45 g. The sand's volume with air, which was found by placing the sand in a graduated cylinder, was 10.4 mL. The sand's volume without air, which was found using the water displacement method, was 6.0 mL.

A 2. The density of the sand with air was found to be 1.49 g/ mL, and the density of the sand alone was 2.6 g/mL. The sand with the air had a lower density than the sand alone. The equation for density is mass divided by volume. For both density calculations, the mass of the sand was the same. However, the volume of the sand with the air was larger than the volume of the sand alone. This is because the grains of sand were separated by air, which made the volume larger than it would be if air was not present. Since the volume of the sand with air was larger, it had a lower density.

D 3. Our answers were compared with those of four other groups.

group #1:	density with air	1.4 g/ mL
	density without air	2.5 g/ mL
group #2	density with air	0.65 g/ mL
	density without air	1.02 g/ mL
group #3	density with air	3.0 g/ mL
	density without air	1.5 g/ mL
group #4	density with air	1.49 g/mL
	density without air	2.73 g/mL

E 4. Three out of the four groups we compared results with had answers very similar to our own. One group, #2, had results that were very different. Since density is an intensive property, the difference in sample sizes among the other groups should not have affected the results. Other groups also may have made errors in their measurements or in their procedures. By double-checking each group's measurements and calculations, it would be possible to determine which group had the most accurate results.

F 5. The procedure utilized in this lab would work well for small, irregular solids such as sand. Many objects, however, would be far too large to place in a graduated cylinder and use the water displacement method. In their instance larger containers could be used. It also would also be much easier to determine the density of regular solids using calculations of length, width, and other dimensions in conjunction mathematical formulas. This method was extremely successful in this example.

Sample 1 (cont.)

GSE SELF-REFLECTION SHEET

GSE Self-reflection Sheet: Problem-solving Investigation

1. *Thoroughly* explain the scientific concept you are investigating in this entry. Give specific examples that show how this concept relates to your Problem-solving Investigation.

B

The purpose of this experiment was to determine the density of sand with air around it and the density of sand alone. The main concept in this lab is how the density of a substance is affected by its mass and volume, namely through the presence or the absence of air around the sand when determining the volume of the sample. This investigation introduces the idea that density is an intensive property, a concept that is reinforced by providing for different groups to use varied amounts of sand when performing these calculations. Density of a given substance remains constant regardless of the size of the sample used./

2. Describe, *in detail*, the part or parts of this investigation YOU personally designed.

This lab contained only a purpose, not a procedure. It was up to the students to design the entire method of determining the density of the sand both with and without air. I designed the plan to use the water displacement method for the volume of the sand without air, and to simply place the sand in a graduated cylinder in order to find it's volume with air. Please see the procedure section on page 1.

3. Describe how the scientific concept you investigated in this component is related to a real-world issue or personal experience (you may include issues that affect society or the environment).

C

The difference in density of objects around us is an integral part of our world. It would be rather difficult to float in the bathtub if water's density were as low as that of air, and just as difficult if water had a density similar to that of a solid. In the same way, it is crucial to our way of thinking and living that density be an intensive property. If the density of a given substance varied with the size of the sample measured, the results could be catastrophic. Imagine buying a 4"x4"x4" block of wood with which to build your home, and finding it to be of a much different consistency and stability than a 50"x50"x50" block of the same type of wood! Everyday we rely on the properties of density for our most basic functions and activities. This experiment simply made us aware of them.

Sample 1 (cont.)

GSE Self-reflection Sheet: Problem-solving Investigation (cont'd)

4. Describe how working with others on this investigation helped to increase your understanding of science.

Although a hypothesis was not necessary in this investigation, my group worked together to develop a procedure in order to fulfill the purpose of this experiment. My partner and I brainstormed for a great length of time, debating the most efficient set-up and procedures to achieve the most accurate results. This involved many ideas being rejected as inefficient or inaccurate. For example, our first instinct was to simply spill the sand out onto the triple beam balance when determining its mass. Careful thought and discussion, however, caused us to realize that this would result in lost sand and therefore inaccurate results. We then devised a more accurate plan of weighing the sand within the cup, and then removing the sand from the cup and weighing the cup alone. We then subtracted the mass of the empty cup from the mass of the cup and the sand, and indirectly determined the mass of the sand. The entire procedure for this investigation was the result of a collaborative effort between my partner and I. G

more

5. What did you conclude from the investigation? Was the conclusion the same as or different from what you expected? Describe how your observations and data support your conclusions.

From this investigation, we concluded that a sample of sand has a lower density when it is surrounded by air than when air is not present. My partner and I found sand surrounded by air to have a density of 1.49 g/mL, whereas sand that was not surrounded by air had a density of 2.6 g/mL. My partner and I found it interesting to discover that the presence or absence of air affects the density of a substance. This discovery was shown by the difference in our calculations of the density of the sand with air and without air. By comparing our results with those of other lab teams, we concluded that density is an intensive property. Although all of the teams used different amounts of sand in their calculations, their results were very similar, and in some cases identical to our own. This means that the density of a given substance does not change with the size of the sample measured.

H In chemistry, as in most areas in life, collaborative efforts achieve the most accurate results in the most efficient manner. Working with a partner or a with a group enables individuals to master concepts and ideas that would be difficult or impossible for them to understand on their own. While brainstorming ideas for the procedure, my partner and I were able to "bounce" ideas off of one another and receive feedback and new ideas in return. In the same manner, if one partner had overlooked a small detail that might impede the obtaining of accurate results, the second partner was quick to see that potential problem and propose a solution. Through exchanging ideas, critique, questions, and information, my partner and I were able to understand the concepts presented in this investigation.

Sample 2

03-12-99

Mas Volimik Sab:

1. Objektif:

Nan esperyans saa, Objektif mwen se pou mwen jwenn yon jan Pou mwen Kalkile mas volimik sab ak lè ak mas volimik sab san lè.

2. Materyèl:

Pou mwen te fè esperyans saa, mwen te itilize: Beche, tib gradye, antonwa, sab, dlo, espatil avèk yon balans.

3. Machasuiv:

Premye bagay mwen te fè, se te Pran yon Kantite sab. Mwen mete sab la nan yon beche, mwen pran pwa beche a anvan epi mwen pran pwa tou de ansanm. Apre sa, mwen vide menm sab la nan tib gradye a, epi mwen mezire volim sab la.
Mwen anrejistre rezilta mwen yo, epi mwen divize pwa sab la ak volim sab la pou mwen jwenn mas volimik sab la ak lè.

Dezyèm bagay mwen te fè, se vide enpe dlo nan tib gradye a, epi mwen mezire volim dlo a. Lè fini, mwen

Sample 2 (cont.)

vide menm kantite sab mwen te itilize nan premye pati esperyans lan nan tib gradye ki gen dlo a mwen bwase yo ansanm pou mwen ka retire lè ki nan sab la. Mwen mezire volim dlo a ansanm ak sab la epi mwen fè soustraksyon pou mwen kapab jwenn volim sab la poukont li. Rezilta mwen jwenn nan se volim sab la san lè.

Pou mwen fini, mwen divize pwa sab la ak volim sab la san lè pou mwen jwenn mas volimik sab la san lè.

4. Rezilta:

(1) Pwa tib gradye a ⇒ 49.4g
(2) Volim sab la ⇒ 2ml
(3) Pwa sab la avèk tib la ⇒ 52.6g
(4) Pwa sab la ⇒ 3.2g
(5) Mas volimik sab la ak lè ⇒ 3.2g ÷ 2ml = 1.6g/ml
(6) volim dlo a ⇒ 5ml
(7) volim sab la ak dlo ⇒ 6.2ml
(8) volim sab ⇒ 6.2ml − 5ml = 1.2ml
(9) Mas volimik sab la san lè ⇒ 3.2g ÷ 1.2ml = 2.7 g/ml

J

5. Konklizyon:

Lè mwen fin fè esperyans sa, mwen vin wè ke mas volimik sab san lè plis ke mas volimik sab ak lè. Konklizyon mwen tire sèke si ou ta pran menm volim sab ak lè ak sab san lè, sab ki pa gen lè ladan l' nan ap peze plis pase sab ki gen lè ladan l' nan.

Sample 2 (cont.)

MAS VOLIMIK* SAB

Travay an gwoup pou w planifye yon esperyans ki pou pèmèt ou chèche mas volimik sab ak lè ki antoure chak grenn sab yo ak mas volimik sab ki pa gen lè ladan l. Fè esperyans lan an gwoup oubyen poukont ou. Ekri yon rapò sou esperyans lan.

ANN REFLECHI SOU ESPERYANS LAN

Lè ou fin ekri rapò sou esperyans lan, reponn kesyon sa yo:

1. Esplike konsèp syantifik ou te envestige nan esperyans lan.

Konsèp syantifik mwen envestige nan esperyans lan se mas volimik. Mwen te vle konnen si sab san lè pi lou ke sab ak lè yo gen menm volim.

2. Ki rapò ki genyen ant konsèp syantifik sa a ak lavi toulejou?

Rapò ki genyen ant konsèp syantifik sa a ak lavi toulejou sèke ou konn bezwen matèryèl ki genyen diferan mas volimik selon travay ou vle fè a. Pa egzanp, si ou vle fè yon avyon oubyen yon bato, ou bezwen yon matèryèl ki solid men ki pa two lou.

3. Esplike kouman travay an gwoup ede w nan rechèch sa a e kouman li ede w konprann konsèp syantifik lan pi byen.

Travay nan gwoup ede mwen paske nenpòt erè mwen te fè, yon lòt moun nan gwoup la wè erè a, epi nou korije li ansanm.

4. Ki konklizyon ou tire nan rechèch la? Èske se sa ou te panse k ap rive? Esplike kouman konklizyon w lan baze sou done ou te ranmase yo.

Konklizyon mwen tire de esperyans mwen an sèke lè ou genyen 2 kalite sab ki gen menm volim, sab ki san lè a ap toujou pi lou ke sab ki ak lè a.
Lè mwen di de kalite sab, mwen vle di:
1 sab ak lè.
2 sab san lè.

* Mas volimik - density

Sample 2 translation

Chemistry Report

Density of Sand

1. Objective:

In this experiment, my objective is to find the density of sand in the presence of air and without the presence of air.

2. Materials:

To do this experiment, I used: beaker, graduated cylinder, funnel, sand, scale, water.

3. Procedure:

The first thing I did was to take a certain quantity of sand. I poured the sand into a beaker. I weighed the empty beaker before weighing it together with the sand. Then, I poured the same amount of sand (from the beaker) into a graduate cylinder and I measured the volume of the sand.

I recorded the results. Then I divided the weight of the sand into its volume to find its density in the presence of air.

The second thing I did was to pour some water into the graduate cylinder, then I measured the volume of the water. When I finished, I poured the same quantity of sand I had used in the first part of the experiment into the graduate cylinder that contains the water. I stirred them (water and sand) up so that I could get rid of the air in the sand. I measured the volume of the water together with the sand, then I did a subtraction to find the volume of the sand by itself. The result I found was the volume of the sand without the presence of air.

To finish, I divided the weight of the sand by the volume of the sand to find the density of the sand without the air being present.

4. Results:

1)	Weight of the graduate cylinder	49.4g
2)	Volume of the sand	2ml
3)	Weight of the sand	3.2g
4)	Weight of the sand and the cylinder	52.6g
5)	Density of the sand with air	3.2g/2ml=1.6g/ml
6)	Volume of water	5ml
7)	Volume of the sand and water	6.2ml
8)	Volume of sand	6.2ml–5ml=1.2ml
9)	Density of the sand without air	3.2g/1.2ml=2.7g/ml

J

5. Conclusion:

When I finished with the experiment, I realized that the density of the sand without air is more than the density of the sand with the air. The conclusion I drew is that if you consider the volume of the sand with air and the volume of the sand without air, the sand without air weighs more than the sand with air.

Sample 2 translation (cont.)

DENSITY OF SAND

Work in a group to design an experiment to determine the density of sand with air around the sand granules and then the density of the sand alone. Write a report based on the experiment.

LET US REFLECT ON THE EXPERIMENT

Answer the following questions after completing your report:

1. Describe the scientific concept you have investigated in the experiment.

The scientific concept I investigated was density. I wanted to know if sand without air is heavier than sand with air when they have the same volume.

2. Describe how the scientific concept you have investigated is related to everyday life.

The relationship between this scientific concept and everyday life is that you sometimes need materials that have different densities depending on the type of work you want to do. For example, if you want to make an airplane or a boat, you need a material that is strong but not too heavy.

3. Describe how working in a group helped to increase your understanding of the scientific concept.

Working in a group helped me because whatever mistake I made, another member of the group was able to see it, and together we were able to correct it.

4. What did you conclude from the investigation? Was the conclusion the same as or different from what you expected? Describe how your observations and data support your conclusion.

The conclusion that I drew from this experiment is that when you have 2 types of sand with the same volume, the sand without air will always be heavier than the sand with air. When I say two types of sand, I mean:

1) sand with air
2) sand without air

The task[215]

The students were asked to describe how to find the density of different substances.

Circumstances of performance

This sample of student work was produced under the following conditions:

alone	√	in a group
in class	√	as homework
with teacher feedback		with peer feedback
timed		opportunity for revision

This work sample illustrates a standard-setting performance for the following parts of the standards: [216]

S1b Physical Sciences Concepts: Structure and properties of matter.

S5e Scientific Thinking: Evaluate the accuracy, design, and outcomes of investigations.

S6a Scientific Tools and Technologies: Use technologies and tools.

S7a Scientific Communication: Represent data and results in multiple ways.

S7e Scientific Communication: Communicate in a form suited to the purpose and the audience.

What the work shows

S1b Physical Sciences Concepts: The student produces evidence that demonstrates understanding of the structure and properties of matter....

(A) Here, and throughout the work, the students show their understanding of density.

S5e Scientific Thinking: The student identifies problems, proposes...solutions....

(B) The students point out that customary technique for finding the volume of an irregular solid, water displacement, which they used for the rock, will not work for solids with densities less than water. They propose a reasonable solution to that problem by suggesting that the less dense solid be attached to a very dense solid, such as iron, so that the combined density would be greater than water. Thus, the combined solid would sink.

S6a Scientific Tools and Technologies: The student uses technology and tools...to observe and measure objects...directly and indirectly...with appropriate consideration of accuracy and precision.

(C) Attention to accuracy is evident in the care taken with significant digits.

(D) (E) Attention to precision is evident in the comments about holding and reading a ruler and reading the level of the graduate cylinder.

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[215] For related work on Density, see “Flinkers”, page 76, “Discovering Density”, page 209, and “Density of Sand”, page 412.

[216] The quotations from the Science performance descriptions in this commentary are excerpted. The complete performance descriptions are shown on pages 292-339.

S7a Scientific Communication: The student represents data and results in multiple ways, such as…tables, and graphs;…diagrams….

(C) The table is well designed to show which values were measured and which were calculated.

S7e Scientific Communication: The student communicates in a form suited to the purpose, such as by writing instructions that others can follow….

Throughout the work, especially at (D) and (E), the instructions are very straightforward and easy to follow.

如何测量物质的密度

我们生活在由物质构成的客观世界中，不同的物质具有不同的特性，因而构成了各种各样的物体。

物质的特性是多种多样的，如气味、颜色、光泽、软硬程度等，它们都可以做为鉴别物质的依据。密度也是物质的一种重要特性，不同物质的密度一般不同。鉴别物质时，也可以先测定出该物质的密度，用测量值与密度表进行对照，往往可以确定它是什么物质。例如，宇航员从月球上采集到的物质标本，地质勘探队员找到的矿石常常要通过测定它们的密度，作为鉴别它们是由什么物质构成的一个依据。在生活中，我们可以利用测量密度，鉴定金首饰的含金量。

A 单位体积的某种物质的质量叫做物质的密度。根据密度的定义，密度的公式可表示为：

$$密度 = \frac{质量}{体积}$$

字母 d 表示密度，m 表示质量，V 表示体积，则：

$$d = \frac{m}{V}$$

密度的单位常用克/厘米³ 或 克/毫升表示。

物质有固、液、气三态。测量不同状态物质的密度，需用不同的方式。

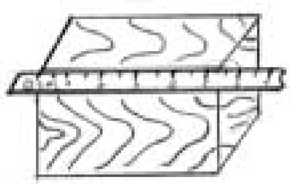
2.

一、测量固体的密度.(器材:天平、刻度尺、量筒、水、长方体金属块、石块)

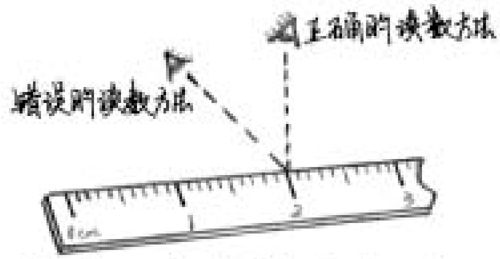
1. 测量形状规则物体的密度.(长方体金属块)

(1). 用天平称出它的质量m.

(2). 用刻度尺量出它的长、宽、高,用公式$V=L\cdot W\cdot H$算出体积V,最后用公式$d=\frac{m}{V}$则可得出密度..



D 刻度尺要尽量贴近被测物体,刻度尺不要歪斜,要与被测物体平行.



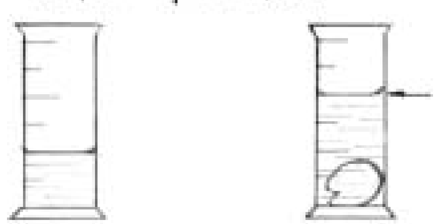
读取数据时,视线要与刻度尺的尺面垂直.

2. 测量形状不规则但密度大于水的物体(石块)

(1). 用天平称出它的质量m.

(2). 在量筒中盛水,读出量筒中水的体积V_1,将物体浸没在水中,读出液面示数V_2,物体的体积为$V=V_2-V_1$.

(3). 用公式$d=\frac{m}{V}$,得出物体的密度..



在读取数据时,读出凹月面最低点的刻度..

E

3.

二、测量液体的密度（器材：天平、量筒、待测液体）

(1). 先用天平称出空量筒的质量m_1.

(2). 将待测液体倒入量筒，称出待测液体与量筒的总质量m_2，待测液体的质量为$m=m_2-m_1$.

(3). 读出液体的体积

(4). 利用公式$\rho=\frac{m}{V}$算出该液体的密度.

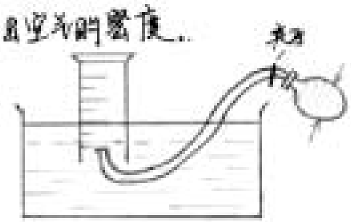
三、测量空气的密度（器材：球胆（或皮囊）连接一根带夹子的胶管、天平、水槽、量筒、水、打气筒）

(1). 取一个球胆（或皮囊）接一根带夹子的胶管，空气打入后，用天平称出它们的质量m_1.

(2). 用下列装置（如图），用力挤压球胆，用排水集气法，在量筒中收集气体，集气完毕后，捏紧夹子，上下移动量筒，使其内外水平面一样高，以保证气体压强与外面大气压相同，然后由量筒刻度读出气体的体积V.

(3). 称出余下气体与球胆的质量m_2，则收集在量筒内气体的质量为$m=m_1-m_2$

(4). 利用公式$\rho=\frac{m}{V}$算出空气的密度.



4

C

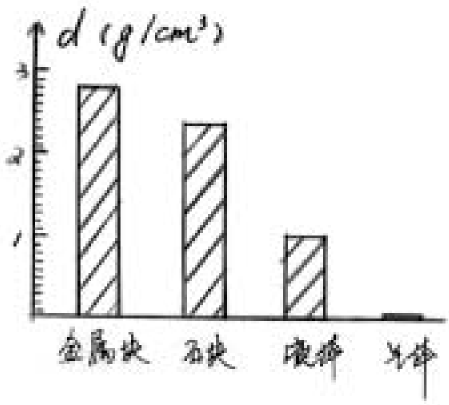
数据记录如下：

物体	质量(g)			体积(cm³)				密度(g/cm³)
				长(cm)	宽(cm)	高(cm)	体积	
金属块	180.01			7.4	5.4	1.6	63.94	2.83
				水	水和石块	石块		
石块	41.81			400	417.5	17.5		2.39
	量筒	量筒和液体	液体					
液体	266.90	564.61	297.71	300.0				0.99
	球胆和空气	球胆	空气					
空气	81.86	81.60	0.26	260.0				0.001

把测出的结果与密度表相对照，可以得出：

结论：金属块是铝，石块是花岗岩，液体是水

实验中的误差是不可避免的，但我们应该尽量减小。上述物体的密度表示如下图：



5

由上述测量结果可知，气体的密度最小，其次是液体，固体的密度最大。所以，大多数固体在液体中下沉。实际上，也有些固体的密度小于液体，比如木块和冰的密度就小于水的密度，将它们放入水中会上浮。那么，如何测量这些固体的体积呢？例如，测量形状不规则的木块体积时，我们可先用细线将木块与铁块系在一起，这样木块就能全部浸入水中，用浸水法测量即可。

你能想出如何测量水的密度的方法吗？

Translation

HOW DO WE FIND THE DENSITY OF THE DIFFERENT MATTER?

We live in an objective world consisted of numerous matter. The different matter is characterized by different properties, thus it results in the formation of a variety of objects which are, in turn, formed by matter.

Matter has certain pertinent characteristics, such as smell, color, luster, and hardness, etc. According to these characteristics, the matter could be identified. Density is also an important characteristic of the matter. Usually the density varies with the different matter. An unknown matter could be identified by finding its density and then comparing the densities of substances. For instance, the specimen collected by astronauts from the moon and the rocks collected by geologists are always identified based on their densities. We also can determine the gold content in a specific gold jewelry by its density.

A Density is the mass per unit volume of an object. According to the definition, the formula of the density is expressed as:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}} \qquad \text{or} \qquad D = M / V$$

The density is expressed in grams per cubic centimeter (g / cm^3) of grams per milliliter (g / ml).

Matter exists in one of three phases — solid, liquid, or gas. We can measure the density of matter in any phase by using the certain method. Let's do the following experiments to find the densities of different objects in different phases.

Materials: balance, ruler, graduated cylinder, metal rectangular prism , rock, and water.

A. <u>To Find the Density of a Solid</u>

1. Metal Prism, a Regular Shape Solid

-1-

Translation (cont.)

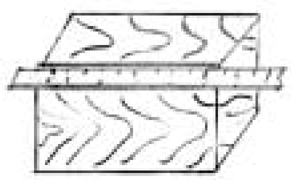
Procedure:

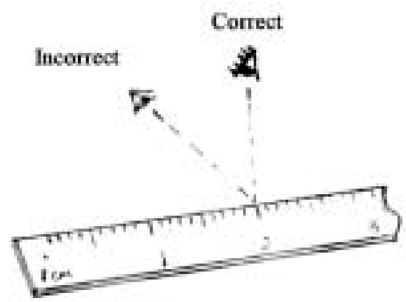
(1) Use the balance to measure the mass of the metal prism.

(2) Use the ruler the measure the length, width and the height of the metal prism.

(3) Calculate the volume of the metal prism by the formula $V = l \bullet w \bullet h$.

(4) Find its density by the formula $D = M / V$.





D

The scale mark should be as close to the object as possible. Keep the ruler to be parallel to the edge being measured.

The view of vision should be perpendicular to the scale.

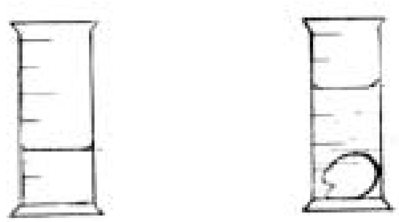
2. Rock, an Irregular Shape Solid

Procedure:

(1) Use the balance to measure the mass of the rock.

(2) Pour some water into the graduated cylinder and read the volume of the water, V_1. Submerge the rock into the water completely and read the total volume, V_2. Then the volume of the rock is $V = V_1 - V_2$

(3) Calculate the density of the rock by $D = M / V$



Read the level of the meniscus

E

-2-

Translation (cont.)

B. To Find the Density of a Liquid

Materials: balance, graduated cylinder, and unknown liquid

Procedure:

(1) Use the balance to measure the mass of the empty graduated cylinder, M_1

(2) Pour the liquid into the graduated cylinder and then measure the total mass M_2. The mass of the liquid is $M = M_1 - M_2$.

(3) Read the volume of the liquid in the graduated cylinder.

(4) Calculate the density of the liquid by $D = M / V$

C. To Find the Density of a Gas

Materials: balance, balloon, rubber tube with a clip, water trough, graduated cylinder, water, and air pump

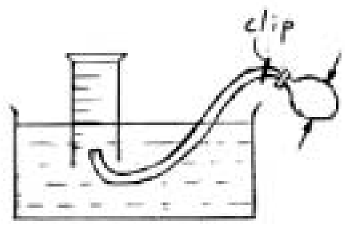
Procedure:

(1) Connect the balloon with the rubber tube and pump the air into the balloon. Then use the balance to measure the mass of this balloon set, M_1.

(2) Set up the equipment as the diagram shown below. Collect some air in the graduated cylinder by squeezing the balloon and then clip the tube. Move the graduated cylinder until the level of water inside as the same as outside so that the air pressure inside is equal to outside. Read the volume of the collected air, V.

(3) Measure the mass the balloon set again, designated as M_2. The mass of the air in the graduated cylinder is $M = M_1 - M_2$.

(4) Calculate the density of the air by $D = M / V$.



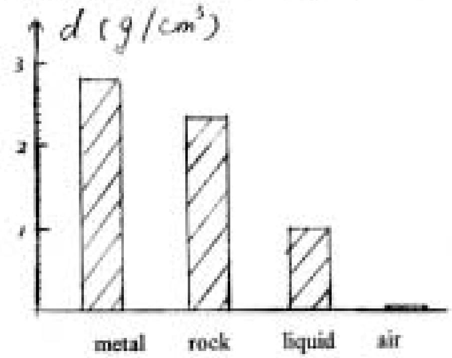
-3-

Translation (cont.)

C

Records:

Object	Mass (g)			Volume (cm³)				Density (g / cm³)
Metal Prism				length	width	height	volume	
	180.01			7.4	5.4	1.6	63,94	2.83
Rock				Water	water & rock		rock	
	41.81			400	417.5		17.5	2.39
Liquid	grad.cyl	g.c.&liquid	liquid					
	266.90	564.61	297.91	300.0				0.99
Air	bal.&air	balloon	air					
	81.86	81.60	0.26	260.0				0.001



Conclusions:

Comparing the data from the experiment with the table of densities, we conclude that the metal is aluminum, the rock is granite, and the liquid is water.

A certain degree of aberration is inevitable in any measuring. However, we should minimize errors.

The densities of the four objects is expressed by a bar graph below. We can see through the graph that the order of the densities from least to most is gas, liquid, and solid. That's why most of the solids would sink in the water, but not all solids do. There are some solids whose density could be smaller than that of water, such as wood and ice. They would, instead, float on the water surface. How do we measure the volume of that kind of solids? To measure the volume of wood, for instance, we could rap the wood with a piece of iron together first , so that the wood could be sunk completely after being placed into the water.

B

Can you state the method to find the density of ice now?

-4-