

SI Chemistry - Full Discipline Demo

States of Matter

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Chemistry - Full Discipline Demo
Course	SI Chemistry - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match the terms to the transitions.

Left column (Terms):

- ⌘ Condensation
- ⌘ Deposition
- ⌘ Freezing
- ⌘ Melting
- ⌘ Sublimation
- ⌘ Vaporization

Right column (Transitions):

- Gas to solid
- Gas to liquid
- Liquid to gas
- Liquid to solid
- Solid to gas
- Solid to liquid

Correct answers:

- 1 Deposition 2 Condensation 3 Vaporization 4 Freezing
5 Sublimation 6 Melting

Classify each statement as describing a gas, liquid, or solid phase.

⚡ Can be crystalline or amorphous	⚡ Exhibits surface tension
⚡ Fills the volume of a container, regardless of size of container	
⚡ Has molecules in a constant state of random motion	
⚡ Has molecules in a fixed volume and a fluid shape	
⚡ Has molecules in a fixed arrangement, closely packed	
⚡ Has rapidly moving molecules with no definite shape or volume	

Gas	Liquid	Solid
1	2	3

Correct answers:

1 Fills the volume of a container, regardless of size of container

Has molecules in a constant state of random motion

Has rapidly moving molecules with no definite shape or volume

2 Exhibits surface tension

Has molecules in a fixed volume and a fluid shape

3 Can be crystalline or amorphous

Has molecules in a fixed arrangement, closely packed

Determine whether each molecule exhibits hydrogen bonding or does not exhibit hydrogen bonding.

	Exhibits Hydrogen Bonding	Does Not Exhibit Hydrogen Bonding
⚡ Ammonia	1	2
⚡ Hydrogen chloride		
⚡ Hydrogen fluoride		
⚡ Sodium chloride		
⚡ Water		

Correct answers:

1 Ammonia Hydrogen fluoride Water

2 Hydrogen chloride Sodium chloride

Exploration

The liquid phase of matter has a fixed volume and shape.

- ☐ True
☐ False



Hydrogen bonding is exhibited between water molecules (H₂O) in the liquid and solid phases.

- ☐ True
☐ False



Solids are most stable when they are ____.

- ☐ oxidizers
☐ crystalline
☐ amorphous
☐ melting



Phase changes that release energy include deposition, freezing, and vaporization.

- ☐ True
- ☐ False



A(n) ____ describes temperature changes for a sample passing through different states of matter, and can be used to determine the melting point and boiling point of substances.

- ☐ heating curve
- ☐ intermolecular force
- ☐ van der Waals force



Exercise 1

Describe your results for the melting point of 1-tetradecanol. Were your results consistent? How do your results compare to the published melting point for 1-tetradecanol?

They should get consistent results. The average that HOL recorded was 37.9°C. The published value is 38°C.

Describe what occurs to the particles of a substance when the substance melts. Explain why this occurs.

Some of the van der Waals bonds are broken, allowing the molecules to slide past each other. The substance then has a fluid shape but still a fixed volume. This occurs because the heat energy excites the molecules.

When performing this experiment, when is the 1-tetradecanol in a condensed phase? Explain your answer.

The 1-tetradecanol is in a condensed phase during the entire experiment. Condensed phases are liquids and solids when the van der Waals forces acting on the molecules allow them to move closer together.

Based on your observations of 1-tetradecanol when it reformed a solid after melting, does 1-tetradecanol form a crystalline or amorphous solid? Explain the difference between these two terms as part of your answer.

Student answers will vary for observations. A crystalline solid has an ordered arrangement of molecules and an amorphous solid does not.

Give some examples of how it might be useful to know the melting or boiling points of a substance. Think in terms of both scientific and commercial/industrial settings.

Scientifically: These properties are useful for identifying chemicals or the purity of a substance.

Commercially: If a substance is used for a purpose, it may need to be in solid, liquid, or gas form to be useful. A substance may need to be stored at a certain range of temperatures.

Describe any possible sources of error for this exercise.

Reading temperature incorrectly, thermometer was not calibrated correctly, or did not notice the exact time that the substance melted. In addition, the thermometer is only marked to the nearest whole degree (Celsius).

Data Table 1: Melting Point of Tetradecanol
(SAMPLE ANSWER BELOW)

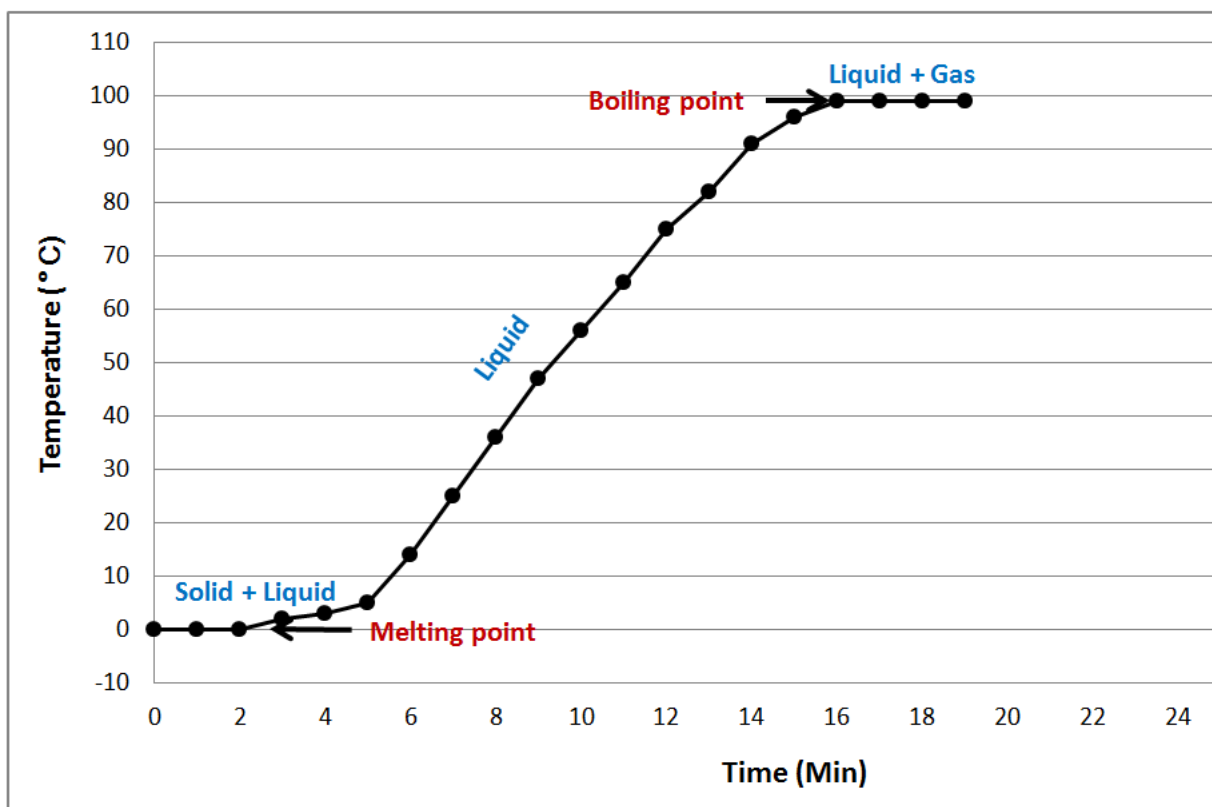
	Melting Point for 1-tetradecanol (°C)
Trial 1	38.5
Trial 2	37.5
Trial 3	37.8
Average of the 3 Trials	37.9

Exercise 2

Using the temperature data recorded in Data Table 2, create a heating curve.

- Plot time (minutes) on the x-axis (horizontal axis) and temperature ($^{\circ}\text{C}$) on the y-axis (vertical axis). Connect the plotted points with a line.
- Label the heating curve to show each phase of matter (solid, solid + liquid, liquid, liquid + gas).
- Label the melting point and boiling point on the heating curve.
- Save an image (jpeg or png) of the graph, or take a screenshot.
- Upload your graph to the panel titled Graph 1: Heating Curve.

Note: An example heating curve is given in Figure 6 in the background information.



Are there parts of the curve with positive slopes and parts that are flat (slope of zero)? What states of matter are present when the slope of the heating curve is positive and what states of matter are present when the slope is zero or close to zero?

Yes, solid and liquid are both present when the heating curve is close to zero for the melting point, and liquid and gas are both present during the boiling point. Between the two on this graph, only liquid state of matter is present.

Describe the key characteristics for the three states of matter.

Solid has a fixed shape and a fixed volume, liquid has a fluid shape and a fixed volume, and gas has a fluid shape and a fluid volume.

Define the melting point. What was the observed melting point of water?

The melting point is the temperature at which a substance changes from a solid to a liquid. The observed melting point was 0°C.

Define boiling point. What was the observed boiling point of water?

The boiling point is the temperature at which a substance changes from a liquid to a gas. The observed boiling point was 99°C.

What happens to heat energy when it is not increasing the temperature of the substance in the beaker? Use your heating curve to explain your answer.

The energy is used to break the intermolecular bonds. This occurs in the melting and boiling periods of the heating curve.

Was temperature perfectly constant during your test while the water was melting and while it was boiling? Explain why or why not.

No, it was not perfectly constant during melting or boiling. The heat from the flame was intense, and even though the water was stirred, the temperature was not entirely constant throughout the mixture.

The published melting point of H₂O is 0°C, and the published boiling point is 100°C. Why may you have found different values?

The pressure of the air may be different than the standard. In addition, other sources of error may include: resting the thermometer on the glass or not stirring the mixture consistently before taking a reading.

Use the following information to determine if the intermolecular forces of isopropyl alcohol are greater or weaker than the intermolecular forces of water. Explain your answer. The melting point of isopropyl alcohol (rubbing alcohol, C₃H₈O) is about -90°C and the boiling point is about 82°C.

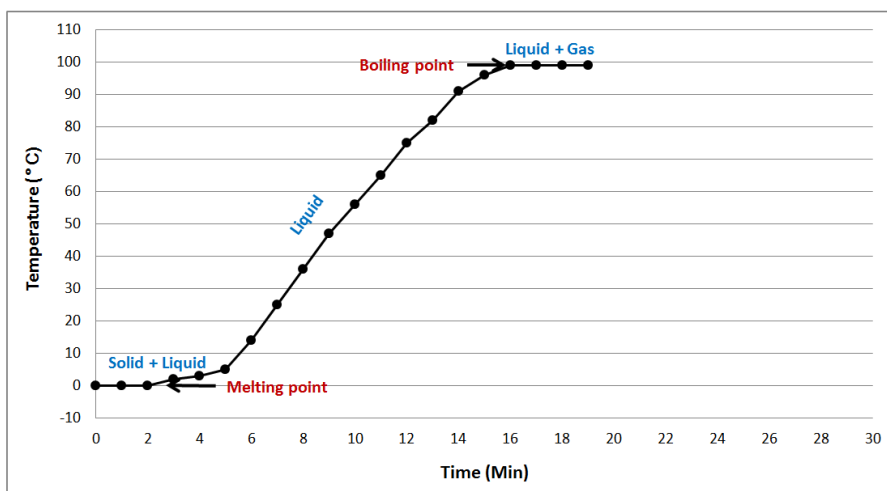
No, they are not quite as strong as water because it takes less energy (heat) to break the intermolecular bonds.

Data Table 2: Temperature and Observations for Heating Curve
(SAMPLE ANSWER BELOW)

Time (Min)	Temperature (°C)	Observations
0	0.0	Solid/Ice
1	0.0	Melting
2	0.2	Melting
3	2.0	Melting
4	3.2	Melting
5	5.3	Melting
6	14.1	All of ice has melted: liquid only
7	25.3	Liquid
8	36.2	Liquid
9	47.0	Liquid
10	56.1	Liquid
11	65.4	Liquid
12	75.3	Liquid
13	82.0	Liquid
14	91.3	Liquid
15	96.2	Boiling

16	99.0	Boiling
17	99.1	Boiling
18	99.0	Boiling
19	99.2	Boiling
20		
21		
22		
23		
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29		
30		

Graph 1: Heating Curve
(SAMPLE ANSWER BELOW)



Exercise 3

In this experiment, there were two possible identities for the gas produced: hydrogen or chlorine, which have quite different properties. Hydrogen is a colorless, odorless, flammable gas. Chlorine gas is greenish yellow with a pungent, bleach-like odor and is non-flammable. Use your observations to determine which gas was produced in this experiment.

Hydrogen was produced and it is flammable. The students should have heard a “pop” from the hydrogen gas in the flame.

As gas moved into the pipet bulb, where did the water go?

The water trickled down the side of the tube as it was displaced by the gas.

Explain why the production of a gas in this experiment is or is not different from the formation of water vapor in the heating curve experiment.

It is different because the gas production in the heating curve experiment was the result of a phase change and the gas produced in this experiment was the result of a chemical reaction.

Data Table 3: Observations of Gas Reactions
(SAMPLE ANSWER BELOW)

Chemicals	Observations
HCl	Clear, colorless liquid
Zn	Silver metal, semi-shiny

HCl + Zn Reaction	Bubbles form
Gas + Flame	In the flame, the gas creates a "pop," showing flammability

Competency Review

A ____ phase of matter has no fixed volume or shape.

- ☐ solid
- ☐ liquid
- ☒ gas

✓

Intermolecular forces are generally weaker than ionic or covalent bonds.

- ☒ True
- ☐ False

✓

When water molecules interact, the ____ charged hydrogen end of one molecule is attracted to the ____ charged oxygen end of another molecule.

- ☒ positively, negatively
- ☐ negatively, positively

✓

Liquids have distinct properties including ____.

- ☐ surface tension
- ☐ viscosity
- ☐ vapor pressure
- ☒ all of the above

✓

Crystalline solids have a disorderly configuration of particles.

- ☐ True
- ☒ False

✓

A phase change from a gas to a solid is known as ____.

- ☒ deposition
- ☐ condensation
- ☐ sublimation
- ☐ vaporization

✓

When pressure is decreased, a substance is more likely to undergo ____ or ____.

- ☐ deposition; condensation
- ☐ melting; freezing
- ☒ vaporization; sublimation

✓

There is ____ in the temperature of a substance at the melting and boiling points during the melting or boiling process.

- ☒ no change
- ☐ an increase
- ☐ a decrease

✓

In order to determine the melting point of tetradecanol, it was important that ____.

- ☒ the thermometer was attached to the capillary tube
- ☐ the water was frozen
- ☐ the capillary tube was immersed in the water without the thermometer

✓

In a heating curve experiment, as temperature is increased over time, water is at what phase(s) at or near a temperature of 0°C?

- ☐ Solid
- ☒ Solid or liquid
- ☐ Liquid or gas
- ☐ Liquid

✓

Which gas is considered flammable?

- ☒ Hydrogen
- ☐ Chlorine



Extension Questions

If Sara was planning a wedding and wanted to have a sculpture of a heart made of butter at the reception, describe how Sara could test the temperature range at which the heart would remain a solid. (SAMPLE ANSWER BELOW)

Sara would prepare a heating curve for butter, to determine the temperature range that the butter would remain in a solid form, and identify the specific melting point temperature that the butter sculpture would begin to melt.