

SI Organic Chemistry - Full Discipline Demo

Isolation and Purification of Caffeine

Final Report - Answer Guide

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

Test Your Knowledge

Categorize each substance by whether it does or does not contain caffeine.

	Contains Caffeine	Does not contain caffeine
☐ Water	1	2
☐ Coffee beans		
☐ Maté		
☐ Cacao seeds		
☐ Black tea leaves		
☐ Orange juice		
☐ Apple cider		

Correct answers:

1 Coffee beans Cacao seeds Maté Black tea leaves

2 Water Orange juice Apple cider

Match each term with the best description.

❖ Melting Point	The phase change from solid directly to gas	1
❖ Freezing Point	The phase change from gas to liquid	2
❖ Boiling Point	The temperature that a liquid begins to change to a gas	3
❖ Sublimation	The temperature that a solid begins to change to a liquid	4
❖ Condensation	The temperature that a liquid begins to change to a solid	5

Correct answers:

- 1 Sublimation 2 Condensation 3 Boiling Point 4 Melting Point
5 Freezing Point

Match the purification technique with the principle of separation.

⌘ Crystallization		Using a compound's solubility in a solvent to slowly precipitate out of solution	1
⌘ Chromatography		Using a compound's boiling point to purify	2
⌘ Distillation		Using two immiscible solvents to separate compounds based on their solubility in the selected solvents	3
⌘ Extraction		Using a compound's affinity for a stationary phase to separate compounds	4

Correct answers:

1 Crystallization 2 Distillation 3 Extraction 4 Chromatography

Exploration

The phase change of a solid directly to a gas is called ____.

- ☐ melting
- ☐ boiling
- ☒ sublimation
- ☐ None of the above



The phase changes from solid to liquid to gas are caused by the molecules vibrating fast enough to overcome the intermolecular forces holding them together.

- ☒ True
- ☐ False



Crystallization is the process of forming a ____, where the atoms or molecules at the molecular level become ____ ordered.

- ☐ gas; more
- ☐ liquid; less
- ☒ solid; more
- ☐ None of the above



In a liquid-liquid extraction two ____ solvents are added to the mixture, and compounds are separated based on their ____ in those solvents.

- ☒ immiscible; solubility
- ☐ miscible; polarity
- ☐ immiscible; molecular mass
- ☐ None of the above



Caffeine can be found in ____.

- ☐ coffee
- ☐ tea
- ☐ guarana
- ☒ All of the above



Exercise 1

Explain why it was necessary to crush the caffeine pills into a fine powder using the mortar and pestle.

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What was the purpose of the dH₂O test tube with 5.0 mL of warm water in this procedure?

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What was the purpose of the dH₂O test tube with 5.0 mL of cold water in this procedure?

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Data Table 1: Caffeine Pills
(SAMPLE ANSWER BELOW)

Mass of caffeine pills (g)	2.35
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Exercise 2

Why were both the solid and the filtrate collected in this experiment?

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What portion, the solid or the filtrate, produced a higher amount of purified caffeine when sublimed? Why is that?

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Data Table 2: Mass of Caffeine
(SAMPLE ANSWER BELOW)

	Mass of cup (g)	Mass of cup + solid (g)	Mass of Petri dish	Mass of Petri dish lid + caffeine (g)	Mass of sublimed solid	Percent Caffeine Isolated (%)
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			lid		(g)	
Solid	2.41	2.90	21.10	21.20	0.10	12.5
Filtrate	2.42	2.50	21.11	21.14	0.03	3.7

Photo 1: Sublimed product from beaker labeled Solid
(SAMPLE ANSWER BELOW)

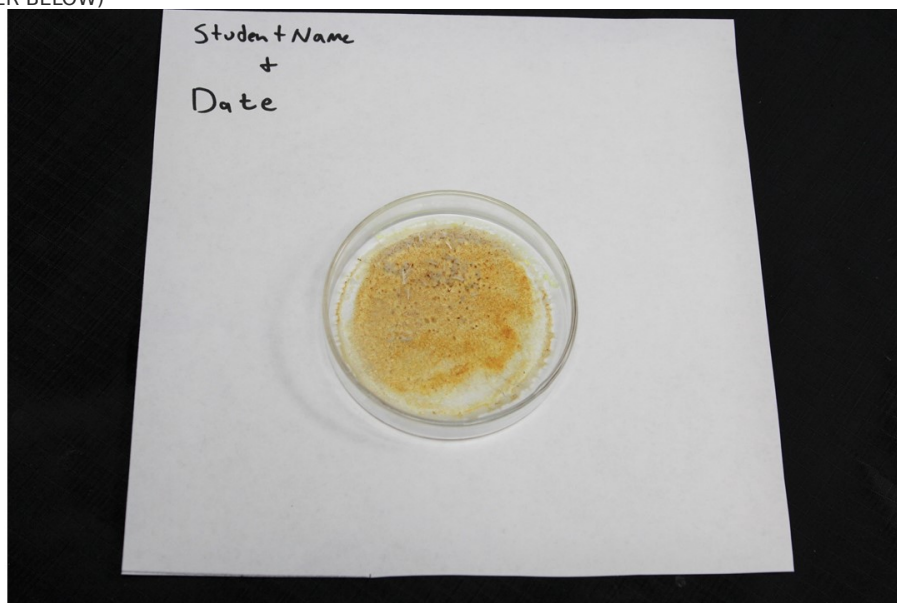


Photo 2: Sublimed product from beaker labeled Filtrate
(SAMPLE ANSWER BELOW)



Competency Review

Caffeine is an organic compound that can be found naturally in coffee beans.

☒ True



☐ False

A chemical transforming from a liquid to a gas is an example of a(n) ____.

☐ freezing point

☒ phase change



☐ recrystallization

☐ None of the above

Crystallization is the process of forming a ____, and the molecules become ____.

☐ liquid; disordered

☐ gas; ordered

☒ solid; ordered



☐ None of the above

Mixing hexanes (an organic solvent) and water with a compound is an example of liquid-liquid extraction.

☒ True



☐ False

In Exercise 1, ____ was the solvent used to extract caffeine from the pills.

- ☐ ethanol
- ☐ hexanes
- ☒ water
- ☐ isopropanol

✓

The solvent used to isolate caffeine should be ____ when combined with crushed pills.

- ☒ hot
- ☐ room temperature
- ☐ cold
- ☐ gaseous

✓

A glass Petri dish and cold water bath can be used to purify dried caffeine precipitates in the ____ process.

- ☒ sublimation
- ☐ liquid-liquid extraction
- ☐ recrystallization
- ☐ None of the above

✓

Pills containing 1.0 g total caffeine were analyzed in the lab, yielding 0.37 g of isolated and purified caffeine. The percent isolation of the techniques was ____.

- ☐ 3.7%
- ☒ 37%
- ☐ 53%
- ☐ 100%

✓

Extension Questions

Industrially, caffeine is commonly extracted from caffeine-containing natural products to produce decaffeinated coffee or tea. The extraction method used in Exercise 1 with hot water is less optimal

with caffeine-containing natural products; instead, organic solvents such as dichloromethane or ethyl acetate are used. Explain why these organic solvent methods are superior for the complex matrix of natural coffee beans or tea leaves compared to the heated water method used in these experiments.

(SAMPLE ANSWER BELOW)

As students should know from making coffee or tea themselves, extracting beans or tea leaves with hot water extracts way more than just caffeine--it takes most of the flavors with it in one extraction. The organic solvents used instead in industry are much more specific to caffeine, leaving most of the other flavors behind so that the decaffeinated coffee or tea tastes largely the same for the consumer.