# Separating caffeine

***Education in Chemistry***May 2021  
https://rsc.li/2QLDAXU

An excellent way to improve your understanding when reading an extended piece of text is to convert the key processes into a series of labelled diagrams or a graphic.

In this activity you will develop this skill by looking at each of the three options for decaffeination in turn and completing graphics of the steps involved in each process.

### 1. Extracting caffeine with organic solvents

a. Add labels to each of the diagrams used to illustrate the step described.

Diagram

Description automatically generatedDiagram

Description automatically generated**Diagram

Description automatically generated**b. Add in an explanation of why that step is needed. The explanation has been added to Step 1 for you as an example.

**Step 1**

Spray the tea leaves with water.

**Explanation**

*To swell the leaves and open their pores to enable the organic solvent to penetrate them.*

**Step 4**

Caffeine is removed from the solvent by distillation.

**Explanation**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Step 3**

The caffeine-laden dichloromethane is driven off the leaves using steam before they are dried to reinstate their original humidity levels.

**Explanation**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Step 2**

Shower the humid tea leaves for 1.5–2.5 hours with dichloromethane.

**Explanation**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Diagram

Description automatically generated**

**Step 4**

Caffeine is removed from the solvent by distillation

**Explanation**

### 2. Extracting caffeine with supercritical carbon dioxide, CO2

For this extraction option, describe the step illustrated by the diagram and add an explanation of why that step is required.

Diagram

Description automatically generated

**Step 1**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Explanation**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Diagram

Description automatically generated

**Step 2**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Explanation**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Diagram

Description automatically generated**

**Step 3**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Explanation**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

### 3. Extracting caffeine with water

Using the graphics given above as examples, draw your own graphic to illustrate the steps involved in extracting caffeine from coffee using water.

## Answers

### 1. Extracting caffeine with organic solvents

**Diagram

Description automatically generated**

**Step 1**

Spray the tea leaves with water.

**Explanation**

*To swell the leaves and open their pores to enable the organic solvent to penetrate them.*

**Step 2**

Shower the humid tea leaves for 1.5–2.5 hours with dichloromethane.

**Explanation**

*To extract the caffeine.*

Diagram

Description automatically generated

Diagram

Description automatically generated

**Step 3**

The caffeine-laden dichloromethane is driven off the leaves using steam before they are dried to reinstate their original humidity levels.

**Explanation**

*To ensure the tea is free of solvent and caffeine and ready to drink.*

Diagram

Description automatically generated

**Step 4**

Caffeine is removed from the solvent by distillation.

**Explanation**

*Separating the caffeine from the dichloromethane means that the dichloromethane can be reused and the caffeine can be purified for use as natural food-grade caffeine.*

### 2. Extracting caffeine with supercritical carbon dioxide, CO2

Diagram

Description automatically generated

**Step 1**

*Swell the coffee beans or tea leaves with steam.*

**Reason**

*To enable the solvent to penetrate the beans or leaves.*

Diagram

Description automatically generated

**Step 2**

*Place the coffee beans or tea leaves in a high-pressure vessel with CO2 and pressurise for a few hours.*

**Reason**

*To selectively extract the caffeine.*

**Diagram

Description automatically generated**

**Step 3**

*Pass the carbon dioxide through active charcoal or into distilled water.*

**Reason**

*To remove the caffeine from the CO2 to allow both to be reused.*

### 3. Extracting caffeine with water

Possible steps that could be illustrated include:

**Step 1** Soak the green coffee beans for 8–10 hours in water that has been pre-saturated with all the soluble solids found in coffee beans apart from caffeine.

**Step 2** Dry the beans.

**Step 3** Pass the water through a carbon filter to recover both the caffeine and the aqueous extract for reuse.