

## **Supporting Information: A Low Cost and Simple Demonstration of Freezing Point Depression and Colligative Properties with Common Salts and Ice Cream**

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### **ABSTRACT**

This material includes a protocol to prepare salt ice cubes, aqueous salt solutions, and ice cream mixtures and a list of supplies.

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# Instructor Guide to Laboratory Preparation

## Materials needed for 1 student

- 1 cardboard lid
- 2 Styrofoam cups
- 1 thermometer
- 5 small plastic bags containing 4 ice cubes each (1 of each salt concentration)
- 1 large plastic bag containing 16 ice cubes
- 1 small plastic bag containing ice cream mixture
- 5 bottles containing salt solution (1 of each salt concentration)

## Important Notes

### Part A

- Use a  $-25\text{ }^{\circ}\text{C}$  freezer at minimum and allow 4 days for the ice cubes to freeze. Consider whether the Epsom salt used is hydrated. Calculations are made assuming a standard 16 slot ice cube tray with approximately 400 mL of liquid.

### Part B

- Allow 4 days for the ice cubes to freeze. If freezer space becomes a problem, pair students into partners or groups.

## Preparing the salt ice cubes

1. For one student to complete the first experiment, 4 ice cubes of each salt concentration are needed. One standard ice cube tray with 16 slots can be filled with 400 mL of liquid. For the following given masses, mix them with 400 g of water. The masses needed for 1, 3, and 5 *m* NaCl ice cubes are 23.38 g, 70.14 g, and 116.91 g, respectively. The mass needed for 1 *m* CaCl<sub>2</sub> is 44.38 g. Since most MgSO<sub>4</sub> salts are hydrated, the amount of added water must be adjusted. For 400 mL of 1 *m* MgSO<sub>4</sub>, mix 98.43 g MgSO<sub>4</sub>•7H<sub>2</sub>O and 349.63 g of water.
2. Place each filled ice cube tray in a freezer. All 1 *m* solutions can freeze in a  $-10\text{ }^{\circ}\text{C}$  freezer, but the 5 *m* NaCl will need a  $-25\text{ }^{\circ}\text{C}$  freezer at minimum. Allow the ice cubes to freeze for 3 to 4 days. The more a freezer is filled, the longer it will take for the ice cubes to freeze.
3. For the first experiment, it is easier to distribute the ice cubes to students quickly if the ice cubes are packed into small plastic bags. Once the ice cubes have frozen, fill labelled plastic bags with 4 ice cubes and place these bags back into the freezer. The ice cubes will start to warm the moment they leave the freezer, so it is imperative to make any transfers as fast as possible.
4. For one student to complete the second experiment, an entire ice cube tray of one salt concentration is needed. Prepare an even distribution of each salt concentration using the masses given in step 1 (ex: if there are 5 students, prepare one ice cube tray of each salt type).

5. Once frozen, transfer all 16 ice cubes from one tray into a labelled large plastic bag and place each bag back into the freezer.

### **Preparing the aqueous salt solutions**

1. For the first experiment, four students can share bottles containing 800 mL of salt solution. The masses needed for 1, 3, and 5 *m* NaCl solutions are 46.75 g, 140.26 g, and 233.76 g, respectively. The mass needed for 1 *m* CaCl<sub>2</sub> is 88.78 g. Mix all of these masses with 800 g of water. If using hydrated MgSO<sub>4</sub> salts, mix 197.18 g MgSO<sub>4</sub>•7H<sub>2</sub>O and 699.12 g of water for 1 *m* MgSO<sub>4</sub>.
2. Place each bottle containing aqueous salt solution into a standard refrigerator to keep it chilled.

### **Preparing the ice cream mixtures**

1. Mix the ice cream packet according to the manufacturer's instructions.
2. Add the same amount of the liquid ice cream mixture to each plastic sandwich bag, for example 200 grams to each bag.
3. Seal the bag and store it in the refrigerator prior to mixing during the experiments.

**Table S1** Supplies for the Freezing Point Depression Experiments

	Total Cost	Quantity	Amount for 1 Expt	Unit Cost (1 Expt)
<b>Consumables</b>				
Epsom Salt	\$5.86	3.63 kg	172.25 g	\$0.28
Table Salt	\$0.40	737 g	227.97 g	\$0.12
Calcium Chloride Road Salt	\$46.20	22.68 kg	77.67 g	\$0.16
Ice cream mix (powder)	\$2.98	226 g	18.83 g powder	\$0.25
Heavy whipping cream	\$3.46	32 oz	40.00 g	\$0.15
Whole milk	\$3.29	128 oz	36.67 g	\$0.04
			<b>Total =</b>	<b>\$1.00</b>
<b>Equipment</b>				
16 cube ice cube trays	\$9.95	4	2.25	\$5.60
12 oz. Styrofoam cups	\$25.99	92	2	\$0.56
Thermometer	\$1.37	1	1	\$1.37
32 oz Plastic bottle	\$89.35	72	1.25	\$1.55
Winter gloves	\$11.99	12	1	\$1.00
Gallon freezer bags	\$4.42	80	6	\$0.33
			<b>Total =</b>	<b>\$10.41</b>

**White Plastic Ice Cube Tray**, \$9.95 for 4, Kitch Fix, Walmart,

[https://www.walmart.com/ip/Kitch-Fix-Easy-Release-White-Plastic-Ice-Cube-Tray-16-Cube-Trays-Pack-of-4/286964849?wmlspartner=wlp&selectedSellerId=101084596&adid=2222222227092404265&w10=&w11=g&w12=c&w13=212126646707&w14=aud-1185573580265:pla-342078645740&w15=1028383&w16=&w17=&w18=&w19=pla&w10=451113258&w11=online&w12=286964849&veh=sem&qclid=CjwKCAjw9-KTBhBcEiwAr19ig3NVIWVV1ALqwyHggupUdOMyydfN3ra-3J4FU9gOYjnLjf2fKhMOghoCj4AQAvD\\_BwE&qclsrc=aw.ds](https://www.walmart.com/ip/Kitch-Fix-Easy-Release-White-Plastic-Ice-Cube-Tray-16-Cube-Trays-Pack-of-4/286964849?wmlspartner=wlp&selectedSellerId=101084596&adid=2222222227092404265&w10=&w11=g&w12=c&w13=212126646707&w14=aud-1185573580265:pla-342078645740&w15=1028383&w16=&w17=&w18=&w19=pla&w10=451113258&w11=online&w12=286964849&veh=sem&qclid=CjwKCAjw9-KTBhBcEiwAr19ig3NVIWVV1ALqwyHggupUdOMyydfN3ra-3J4FU9gOYjnLjf2fKhMOghoCj4AQAvD_BwE&qclsrc=aw.ds) (accessed May 9, 2022)

**Black Winter gloves**, \$11.99 for 12, Amazon, [https://www.amazon.com/12-PAIRS-MAGIC-GLOVES-SIZE/dp/B003W5HJUE/ref=asc\\_df\\_B003W5HJUE/?tag=hyprod-20&linkCode=df0&hvadid=312210011890&hvpos=&hvnetw=g&hvrnd=521311182270410102&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1028383&hvtargid=pla-422177069193&pssc=1](https://www.amazon.com/12-PAIRS-MAGIC-GLOVES-SIZE/dp/B003W5HJUE/ref=asc_df_B003W5HJUE/?tag=hyprod-20&linkCode=df0&hvadid=312210011890&hvpos=&hvnetw=g&hvrnd=521311182270410102&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=1028383&hvtargid=pla-422177069193&pssc=1) (accessed May 9, 2022)

**Epsom Salt**, \$5.86 for 8 lbs., Equate, Walmart, [https://www.walmart.com/ip/Equate-Magnesium-sulfate-USP-Epsom-Salt-8-lbs/690032288?wmlspartner=wlp&selectedSellerId=0&w13=2019&adid=22222222277690032288\\_117755028669\\_12420145346&wmlspartner=wmlt&w10=&w11=g&w12=c&w13=501107745824&w14=pla-](https://www.walmart.com/ip/Equate-Magnesium-sulfate-USP-Epsom-Salt-8-lbs/690032288?wmlspartner=wlp&selectedSellerId=0&w13=2019&adid=22222222277690032288_117755028669_12420145346&wmlspartner=wmlt&w10=&w11=g&w12=c&w13=501107745824&w14=pla-)

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**Iodized Salt**, \$0.40 for 737 g, Great Value, Walmart, <https://www.walmart.com/ip/Great-Value-Iodized-Salt-26-oz/10448316> (accessed May 9, 2022)

**Ice Cream Mix**, \$2.98 for 8 oz, Nostalgia, Walmart, [https://www.walmart.com/ip/Nostalgia-Premium-Chocolate-Ice-Cream-Mix-8-oz/453409703?wmlspartner=wlp&selectedSellerId=0&w13=2852&adid=2222222277453409703\\_117755028669\\_12420145346&wmlspartner=wmlt&w0=&w1=g&w2=c&w3=501107745824&w4=pla-293946777986&w5=1028383&w6=&w7=&w8=&w9=pla&w10=8175035&w11=local&w12=453409703&w13=2852&veh=sem\\_LIA&qclid=CjwKCAjw9-KTBhBcEiwAr19ig5X6gJ97PB16csUkKArDpP5dPykq54pfHHi1hP7wbHvkoWcJ6KjeBoCzqQQAvD\\_BwE&qclsrc=aw.ds](https://www.walmart.com/ip/Nostalgia-Premium-Chocolate-Ice-Cream-Mix-8-oz/453409703?wmlspartner=wlp&selectedSellerId=0&w13=2852&adid=2222222277453409703_117755028669_12420145346&wmlspartner=wmlt&w0=&w1=g&w2=c&w3=501107745824&w4=pla-293946777986&w5=1028383&w6=&w7=&w8=&w9=pla&w10=8175035&w11=local&w12=453409703&w13=2852&veh=sem_LIA&qclid=CjwKCAjw9-KTBhBcEiwAr19ig5X6gJ97PB16csUkKArDpP5dPykq54pfHHi1hP7wbHvkoWcJ6KjeBoCzqQQAvD_BwE&qclsrc=aw.ds) (accessed May 9, 2022)

**Whole Milk**, \$3.29 for 128 fluid oz, Great Value, Walmart, [https://www.walmart.com/ip/Great-Value-Whole-Vitamin-D-Milk-Gallon-128-fl-oz/10450114?wmlspartner=wlp&selectedSellerId=0&w13=3215&adid=222222223710450114\\_126254700153\\_13889847805&w0=&w1=g&w2=c&w3=533487272773&w4=aud-393207457166:pla-325560505822&w5=1028383&w6=&w7=&w8=&w9=pla&w10=8175035&w11=local&w12=10450114&veh=sem&qclid=CjwKCAjw9-KTBhBcEiwAr19ig9C6Dy78FgDHUPX3VCBzt1fNCQwRRtOiEX77pnM\\_aGepVrzZeDUi0xoCPZkQAvD\\_BwE&qclsrc=aw.ds](https://www.walmart.com/ip/Great-Value-Whole-Vitamin-D-Milk-Gallon-128-fl-oz/10450114?wmlspartner=wlp&selectedSellerId=0&w13=3215&adid=222222223710450114_126254700153_13889847805&w0=&w1=g&w2=c&w3=533487272773&w4=aud-393207457166:pla-325560505822&w5=1028383&w6=&w7=&w8=&w9=pla&w10=8175035&w11=local&w12=10450114&veh=sem&qclid=CjwKCAjw9-KTBhBcEiwAr19ig9C6Dy78FgDHUPX3VCBzt1fNCQwRRtOiEX77pnM_aGepVrzZeDUi0xoCPZkQAvD_BwE&qclsrc=aw.ds) (accessed May 9, 2022)

**Heavy Whipping Cream**, \$3.92 for 32 fluid oz, Great Value, Walmart, [https://www.walmart.com/ip/Great-Value-Ultra-Pasteurized-Real-Heavy-Whipping-Cream-32-Oz/10450340?wmlspartner=wlp&selectedSellerId=0&w13=3215&adid=222222227710450340\\_117755028669\\_12420145346&wmlspartner=wmlt&w0=&w1=g&w2=c&w3=501107745824&w4=pla-293946777986&w5=1028383&w6=&w7=&w8=&w9=pla&w10=8175035&w11=local&w12=10450340&w13=3215&veh=sem\\_LIA&qclid=CjwKCAjw9-KTBhBcEiwAr19igzk2sOXSLQGONpRzapqPL7-53qGKJTVDRDQf3kkphosv9GX\\_w9bVRoCyD8QAvD\\_BwE&qclsrc=aw.ds](https://www.walmart.com/ip/Great-Value-Ultra-Pasteurized-Real-Heavy-Whipping-Cream-32-Oz/10450340?wmlspartner=wlp&selectedSellerId=0&w13=3215&adid=222222227710450340_117755028669_12420145346&wmlspartner=wmlt&w0=&w1=g&w2=c&w3=501107745824&w4=pla-293946777986&w5=1028383&w6=&w7=&w8=&w9=pla&w10=8175035&w11=local&w12=10450340&w13=3215&veh=sem_LIA&qclid=CjwKCAjw9-KTBhBcEiwAr19igzk2sOXSLQGONpRzapqPL7-53qGKJTVDRDQf3kkphosv9GX_w9bVRoCyD8QAvD_BwE&qclsrc=aw.ds) (accessed May 9, 2022)

**Round Plastic bottle**, \$89.35 for 72, The Cary Company, [https://www.thecarycompany.com/plastic-packer-bottles-30w33p?utm\\_source=google\\_shopping&qclid=CjwKCAjw9-KTBhBcEiwAr19ig\\_F\\_OZQLxjSa9hX9sqCQ31pQnrJlk\\_2atPCoOw5N-3fkBH4iBm0JiRoChcoQAvD\\_BwE](https://www.thecarycompany.com/plastic-packer-bottles-30w33p?utm_source=google_shopping&qclid=CjwKCAjw9-KTBhBcEiwAr19ig_F_OZQLxjSa9hX9sqCQ31pQnrJlk_2atPCoOw5N-3fkBH4iBm0JiRoChcoQAvD_BwE) (accessed May 9, 2022)

**Thermometer**, \$1.37 for 1, Boafu, Walmart, <https://www.walmart.com/ip/Baofu-Instant-Read-Digital-Electronic-Kitchen-Cooking-BBQ-Grill-Food-Meat-Thermometer-for-Home/295246946?wmlspartner=wlp&selectedSellerId=101115012&adid=2222222227461032977&w0=&w1=g&w2=c&w3=538330430112&w4=aud-393207457166:pla->

