

Winter Woes: Problem Handouts



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Winter Woes

Part 1

For nearly a week the Eastern seaboard had been blasted by what weather forecasters euphemistically called a 'wintery mix': snow, sleet, and freezing rain. The resulting ice-glazed streets and sidewalks sent residents scurrying for aid in the form of shovels, ice choppers, salt, sand, dirt, cat litter—anything to make possible some mode of transportation.

Chris and Lee, the only two of a group of housemates left in Newark during Winter session, tried to avoid the problem for a while, until their dwindling supply of Doritos and Diet Coke made a shopping trip imperative. They gingerly made their way out to the car and, after two hours of hacking away ice from the door and windows, managed to get in. Twisting the key in the ignition, Chris was delighted to hear the battery turn over immediately, and mentally posted a note of congratulations for taking advantage of a battery sale just a few weeks earlier. The engine, however, didn't 'catch' for a while and, when it finally did, ran very roughly, surging and chugging.

"It acts like it's not getting enough gas", Lee noted. "Have you added any 'dry gas' recently?"

"Huh?" Chris responded.

"It's some stuff that you can add to the fuel tank of the car—it's supposed to keep the fuel lines from freezing up", Lee said. "You just toss a bottle's worth in when you tank up, and it eliminates the chugging. My folks swear by it—kept our old car running forever in the winter. We can get some at the gas station."

"But that doesn't make sense", said Chris the theoretician. "Gasoline doesn't freeze at these temperatures - 5 °F is cold, but that isn't enough to freeze gasoline—is it?"

"I think it has something to do with the gas getting wet—at least, I thought that's why they called it 'dry gas'. I don't know—I just know that dry gas always worked for us—whatever the reason, it can't hurt to try."

Questions to consider:

1. In chemical terms, what is gasoline? Given the chemical nature of gasoline, what general expectations do you have about its freezing point? Why?
2. Suppose some water did get into the fuel lines. How would you expect water and gasoline to interact? Will the presence of water change the freezing point of gasoline?
3. The chief ingredient in dry gas is methanol. How might the presence of methanol perturb the gasoline-water system?



Winter Woes

Part 2

After tanking up at the gas station, Chris and Lee slide down to Agway on Main Street to pick up some salt for deicing their sidewalk. They've lucked out—a new shipment just came in. The board over the counter reads:

Rock Salt	\$5.00/ 100 lbs.
Calcium Chloride	\$18.95/ 80 lbs.
Urea	\$8.00/ 100 lbs.

"Now what?" Lee said. "I thought salt was salt; I didn't know there were different kinds!"

"Beats me", Chris agreed. "I heard the traffic guy saying something about it being too cold for salt to work—maybe one of these other things would work better."

4. Draw up a general description of a good deicing agent for streets; be prepared to back up your description using chemical principles.
5. Which material do you think they should buy? How much will they need to clear 100 ft of sidewalk? (The sidewalk is 2. ft wide, covered by one inch of ice. Make any other assumptions you feel are necessary.)



Winter Woes

Part 3

After a few close calls, Chris and Lee managed to make it to the gas station and tanked up. Next, they headed for College Square. While waiting in the checkout line at Pathmark, Lee picked up a copy of the Newark Post and saw the following article:

RECENT RAINS TIED TO STRANGE TASTE IN LOCAL DRINKING WATER

"Newarkers experienced the taste of a summer day at the pool in their drinking water this week. David DeNagy, commercial manager at Wilmington Suburban Water Treatment Plant, said last Friday's heavy rain caused flood conditions at the plant. Water, ice, trees and sticks ran off the streets into the water supply and turbulent conditions caused a lot of mud to be churned into the water. Chlorine and ferric chloride were increased to combat a high bacteria level. "If customers don't smell chlorine they should be more concerned because it's an inhibitor for bacteria", DeNagy said. DeNagy suggested that customers bottle their water and refrigerate it for a couple of hours to dissipate the chlorine. The highly treated water"

"You were right about the chlorine smell, Chris", Lee pointed out. "Better go back for some Evian; I'm not drinking this stuff."

6. Do you agree with the plant manager's suggestion for getting rid of the chlorine in tap water? Explain.
7. The water purification code specifies that the chlorine content of tap water, at the point of delivery, must be at least 1 g of Cl_2 per 1000 kg of water. Express this concentration in units of molarity, parts per million, and molality.
8. How do chlorine and ferric chloride 'combat a high bacteria level'?

Winter Woes

Part 4

Driving back from their errands, Chris and Lee listen to the latest reports of storm-related mishaps on the radio. One in particular catches their attention: a small coastal town farther south had thought itself lucky to catch the warm side of the most recent storm. The resulting torrential rains, however, caused a creek retaining wall to fail. The rampaging creek, cresting a dozen feet above flood level, washed tons of temporarily-stockpiled rock salt into the town's reservoir. Tests showed the salinity of the reservoir to be nearly 3%—almost as salty as ocean water. The news report indicated that the town was considering its options for repurifying the water, including using the facilities of a nearby chemical plant for distilling the water. In the meantime, the local naval base had sent the townspeople an emergency shipment of reverse osmosis desalinators, normally stocked in life rafts, for purifying water at home.

9. Describe what would happen during distillation of the reservoir water. What would the initial boiling point be for a sample of this reservoir water? Why?
10. Suppose the reservoir had been contaminated by a spill of methanol instead of salt. Would this change your answer to the first question in any way?
11. What is meant by reverse osmosis? What is the molecular level basis for this process?
12. Why isn't salt water drinkable?