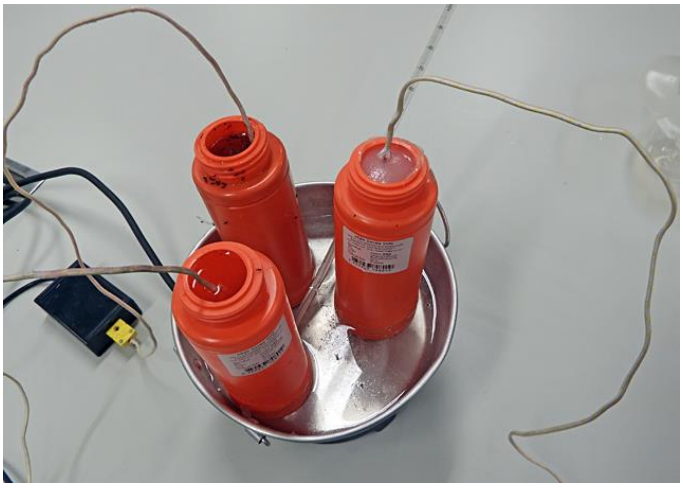
Conceptual questions

Transfer of Heat by Convection

Question 1

Water, honey and agar water-gel fill cylindrical plastic sauce bottles, 15 cm high, 1.2 mm thick and 16.5 cm in circumference. The bottles are in a water-bath at ~70 ºC. The thermocouples are placed centrally one cm below the surface of the filling in each bottle.



Temperature-time curves are shown below.

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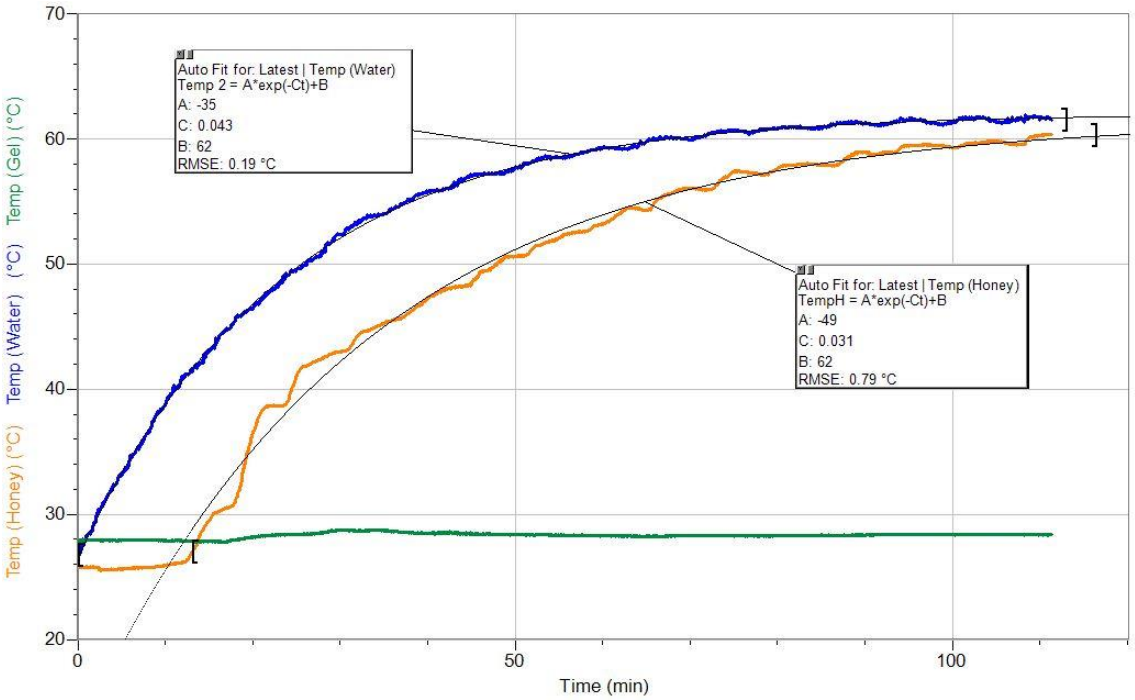


Question 1 continued

Part I

Questions **a-e** refer to the graph and illustration above.

a What might be the reason for the delay in the response of honey?

b Why might the honey curve be more irregular than that of water?

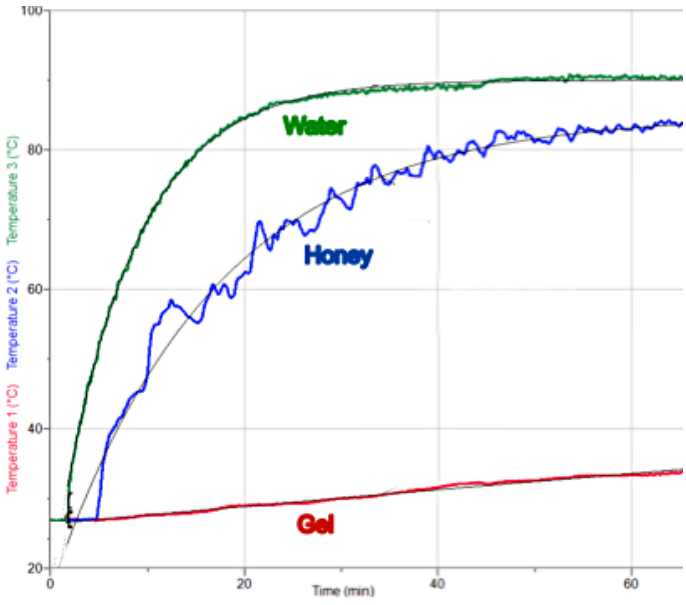
c Why are the top temperatures less than 70º, and why is the top temperature of honey lower than that of water?

d Why (in general terms) are the water and honey temperature-time curves both approximately exponential?

e Why is there very little temperature rise at the top of the water gel column?

Part II

The demonstration was initially set up with tall coke cans as containers in a water bath close to 96°C. The cans were of similar dimensions to the plastic bottles but only 0.1 mm in thickness. It was found that the temperature rise at the top of the gel column was ~5°C, not almost zero as in the graph above.



The thermal conductivity of water is 0.58 W/mK …. of low density polyethylene is 0.33 W/mK …. and of aluminium is 205 W/mK

a Account for the difference in the top temperature in the gel when using coke cans?

You may support your answer with calculations.

Question 2

Falling into cold water far from shore is unpleasant and life threatening.
If the water is down at 4°C or even lower you may have less than an hour to live, depending on the clothing you're wearing and how fat you are.

https://commons.wikimedia.org

We find this advice on the web.

> If you're thin and don't have much body fat, you'll lose heat faster than someone who's overweight and you'll lose heat faster if you thrash about. Unless you can get help fast by shouting and waving your arms stay still and keep as much of your body out of the water as possible. Dunking your head underwater will speed up the heat loss process. If you're wearing a life jacket or have something else to help you float hold your arms in tight and hug your knees to your chest.

a What property of fat is important in this situation?

b The air temperature is probably colder than the water. Why (in terms of the physics) are you advised to keep as much of you out of the water as possible?

c Why exactly (in terms of the physics) are you advised not to try to swim an impossible distance but to stay as still as possible?

d Why exactly (in terms of the physics) are you advised to curl up into a ball as much as possible?

To be continued …