Please record your answers to each portion of the exam on the separate paper provided to you. Write your name on each page, and staple together at the end of the exam.

Data you might need:

Factor for water = 1	Factor for Alcohol = 0.6
Factor for Copper = 0.1	Energy needed to melt 1g of ice = 75 Kelseys

Lab: Liquid nitrogen

Nitrogen is the gas that makes up the majority of air. It is all around us. At very low temperature it is a liquid. This liquid boils (changes from liquid to gas) at a certain very low temperature, you will be given boiling liquid nitrogen, and your job is to **determine the temperature of the liquid nitrogen**.

The challenge is liquid nitrogen is so cold the thermometers we use won't record temperatures that low (it is well below zero on the Celsius scale) and also may break. You will need to plan and carry out an experiment to determine the temperature some other way.

Materials available to you:

- Liquid nitrogen
- Styrofoam cups
- copper cylinder
- hot and room temperature water
- scale
- beakers for measuring volume
- tongs
- thermometers
- computers with temperature probes
- your brain

You don't neceesarily need all these things.
You also don't need to know the "factor" for nitrogen.
Don't put thermometers or probes in the liquid nitrogen!

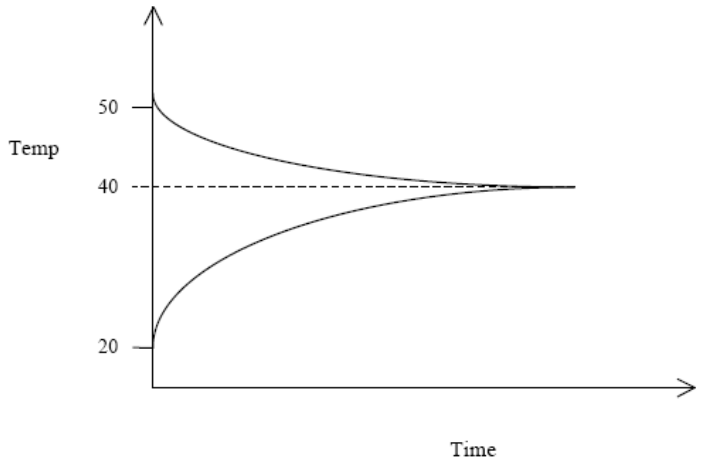
[Problem 1: 15 pts.] Planning: The first thing you need to do is come up with a plan. In your group devise a plan for how to determine the temperature of the liquid nitrogen. If there is some material you would like to use that is not on the list just ask me if you can use it. Once you have your procedure figured out write it down then let me know that you are ready to move on. I want to look at your procedure before you collect your data – write it on your test paper.

[Problem 2: 10 pts.] Collect Data: When I have looked at your plan and discussed it with you, collect the things you will need to conduct your experiment. I will give you a Styrofoam cup of liquid nitrogen. Be careful with it! **It's tremendously cold. Make sure it stays in the cup**. Conduct your experiment, collecting whatever data you have decided to collect. Record your data, clearly labeling it.

[Problem 3: 15 pts.] Conclusion: Make any calculations you need to. Please clearly show everything you do, including the calculations. Write a *brief* conclusion explaining your result. Also, if you have reason to question the accuracy of your result please write a brief explanation why you are questioning it.

Problem 4

Below is a graph of some data that a group in our class could have collected during one of the first experiments. This data would have been collected during the experiment we did where we had some cold water in a plastic baggie and some hot water in a Styrofoam cup, then dunked the baggie in the cup and recorded the temperatures on the computer using the temperature probes.



Just to be clear about this graph, what we intend for it to show is the **hot water starting at 50 degrees, the cold starting at 20 degrees, and then the two temperatures meeting at 40 degrees some time later**.

We want you to figure out some amounts of hot and cold water that would give you this graph. That is, knowing what the initial and final temperatures were, what could the amounts of hot and cold water possibly have been? Explain your reasoning and show us any calculations you choose to make.

Now consider this: Could there be some other amounts which another group could use (keeping the same initial and final temperatures)?

"Wonder Woman Saves Superman." (also known as Problem 5)

Wonder Woman is in a bit of a sticky situation. The green goblin has frozen Superman (who is unconscious and unable to use his powers) in a block of ice. The whole block of ice is kept in a very large Styrofoam container. If Wonder Woman cannot unfreeze Superman very quickly, then he would die (and that as we can all guess would be a bad thing). She cannot wait for the ice to melt by itself; Now Wonder Woman just happens to know that the block of ice (only the ice) weighs 160 kilograms (1 kilogram = 1000 grams; and so 160 kilograms is really 160,000 grams)

Wonder Woman looks around calmly, certain that she is clever enough to figure out how to quickly melt the ice and free Superman. The room also contains a huge vat of boiling isopropyl alcohol, presumably being prepared for some other hapless superhero to be lowered into. She also finds an eight-gallon bucket. Wonder Woman knows that eight gallons of isopropanol weighs 25 kilograms (or 25000 grams, if you prefer that), and that alcohol boils at 80°C (so that is the temperature of the alcohol).

She does a quick calculation, and figures out exactly how many buckets of alcohol to dump on the ice to just melt all of it. Too many, and Superman might get boiled. How many buckets of alcohol does she figure she needs to dump into the Styrofoam container to melt the ice? Please show us and/or explain how you figured out how much alcohol she needs.

Problem 6

Two students, April and Beth, are having a discussion about temperature and energy. April says that "**temperature is like candy**," and gives this example: when 100g of hot water at 60°C is mixed with 100g of cold water at 20°C, the final temperature is 40C. The cold water gained 20C, the hot water lost 20°C. Beth says "no, **energy is like candy**," the hot water lost 2000 Kelseys, and the cold water gained 2000 Kelseys.

Take April's side, or Beth's side, and make a case for which is more like candy: temperature, or energy. Use examples of actual observations you made in class to support your argument. Give a physical reason why the point of view you chose (April's or Beth's) makes sense.

Problem 7

Your lab partner says to you "if I add some energy to a substance, then its temperature must go up." You claim that this isn't true. Give an example of an observation you made in class that illustrates this, and explain why adding energy to a substance might not change its temperature.