Name _______________ Section ________
Partner's Name ____________________

Purpose
The purpose of this lab is to explore the difference between temperature and heat.

Equipment
Thermos or double walled cup (at least 400 ml), graduated cylinder, 500 ml plastic beaker, insulated cup, thermometer, heating coil, small rocks, plastic sandwich bag, 3 or four thin rubber bands (easy to stretch).

Part 1 Difference Between Temperature and Heat

When heat energy is added to a substance like water the temperature of the substance increases. The heat energy delivered by a heater of a certain power output is given by,

Heat Energy = (Power) (time)

Where Heat has units of Joules, Power has units of Watts (Joules/sec) and time has units of seconds. For our lab, you will control the amount of heat added to the system by changing the length of time that the heater is plugged in.

Exp #1.
1. Pour 150 ml **(150 g)** of water into an insulated cup. Place the heating coil in the water, stir the water around with the thermometer, and record the initial temperature of the water. Do Not plug the heater in yet.

T_o = _________________°C

2. Always make sure that the heater is submerged in water before plugging it in. Otherwise it will burn out in about 4 seconds.

Plug the heater in for **60 seconds**, stirring all the time. After 60 seconds, unplug the heater. Keep stirring for another 10 or 15 seconds so the water is completely mixed and then record the final temperature of the water.

T_f = _________________ °C

3. What was the temperature change of the water? **(T_f-T_o)**
Temperature change = __________________°C

Prediction.
If you had twice as much water what would you expect for the temperature change of the water for **60 seconds** of heating?

Exp #2 Using 300 ml (**300 g** since water has a density of 1.0 g/ml) of water Repeat Exp #1. (i.e. add heat to this water for **60** sec)

T_o = _________________°C

T_f=_________________°C

Temperature change = _________________°C

Did your measurement agree with your prediction? Explain any differences.

Question
Comparing **Exp. #1 and Exp #2**:
in which experiment did the heater provide the most heat, #1, #2 or same for both? (remember that the heat added by the heater is related directly to the heating time.)

In which experiment was the temperature rise the largest, #1, #2, or same for both?

Prediction
If you had twice as much water as in **Exp #1** (i.e. 300 g) what would you expect for the temperature change of the water for **120 seconds** of heating?

Exp #3
Test your prediction. Using 300 ml (**300 g**) of water repeat Exp #1 except run the heater for **120.0** sec.

T_o = ________________°C

T_f=________________°C

Temperature change = ________________°C

Did your measurement agree with your prediction? Explain any differences.

Question.
Comparing **Exp. #1 & Exp #3**:
1. In which experiment did the heater provide the most heat, #1 or #3, or same for both? (remember that the heat added is related directly to the heating time.)

2. In which experiment was the temperature rise the largest, #1 or #3, or same for both?

What determines the amount of heat added to a material?

What determines its temperature increase?

What is the difference between heat and temperature?

Prediction
If you had **150 g** of water and **150 g** of rocks in the cup what would you expect for the temperature change of the water and rock mixture for 120 seconds of heating? That is would you expect the **300 g** water/rock mixture to have a smaller or larger temperature rise than you had for experiment #3 (**300 g** of pure water heated for 120.0 second).

Exp #4
Test your prediction. Place **150 g** of water and **150 g** of rocks** in the cup and run the heater for **120.0** sec.

T_o = ________________°C

T_f=________________°C

Temperature change = ________________°C

Did your measurement agree with your prediction? Explain any differences.

** If you don't have a scale you can estimate the mass of rocks by the volume they displace. Let's assume that your rocks have a density of 2.7 g/ml (this is an average density for rocks (make sure you are NOT using pumice stones or porous volcanic rocks). The mass =density x volume so the volume of rocks need to give you 150 g is V=150g/2.7 g/ml=55 ml. So to get 150 g of rock fill a measuring cup or graduated cylinder to a known level and then add enough rocks to raise the level by 55 ml. Another method would be to put 150 ml (150 g since water has a density of 1 g per ml) of water into a plastic bag and suspend it from three or four rubber thin bands linked end to end. Carefully note the total stretch of the rubber bands. Three or four rubber bands linked end to end makes this method fairly precise. Now dump the water out and replace it with enough rocks to give the same stretch.

Question.
Comparing **Exp. #4 & Exp #3**:
1. In which experiment did the heater provide the most heat, #4 or #3, or same for both? (remember that the heat added is related directly to the heating time.)

2. In which experiment was the temperature rise the largest, #4 or #3, or same for both?

3. Analyzing **Exp. #4 & Exp #3**, Which requires more heat energy for a given temperature rise, 150 g of rocks or 150 g of water? That is if you wanted to heat each up by 50 °C, which would require the most energy, 150 g of rocks or 150 g of water?

Questions.

1. The specific heat capacity of a substance is the amount of heat energy needed to raise 1.0 g of that substance by 1.0 °C. In equation form the specific heat capacity C is given by

$$C = \frac{Heat}{mass \cdot \Delta Temp}$$

Substances with a large specific heat capacity take a large amount of Heat energy for each 1°C temperature increase. Alternately, substances with a relatively **large specific heat capacity** will undergo a relatively **small temperature increase** for each Joule of heat energy added.

Which has the largest specific heat, rocks or water? Explain.

2p. **(prediction)** 100 g of cool water at 20 °C is mixed with 100 g of warm water at 60 °C. What is the final temperature of the mixture? Hint: as the hot water cools it gives its energy to the cool water.
a. less than the mid point temperture (40 °C in this case)
b. at or about the mid point temperature
c. more than the mid point temperature

Test your thinking here. Put 100 ml of tap water into an insulated cup and then in another cup put 100 ml of water and heat it up to about 60 ^oC (close to 60 ^oC will be good enough for you to test your thinking). Record the temperature of the tap water and warm water below.

T_{tap}= _______________ T_{warm}=________________ T_{mixed}=______________

Pour the tap water into the warm water and then record the temperature of the mixture.

2t. **(after testing your thinking)** 100 g of cool water at 20 °C is mixed with 100 g of warm water at 60 °C. What is the final temperature of the mixture? Hint: as the hot water cools it gives its energy to the cool water.
a. less than the mid point temperture
b. at or about the mid point temperature
c. more than the mid point temperature

3 p. **(prediction)** 20 g of cool water at 20 °C are mixed with 100 g warm water at 60 °C. What is the final temperature of the mixture?
a. less than the mid point temperture (40 °C in this case)
b. at or about the mid point temperature
c. more than the mid point temperature

Test your thinking here. Put 20 ml of tap water into an insulated cup and then in another cup put 100 ml of water and heat it to about 60 °C (close to 60 °C will be good enough for you to test your thinking). Record the temperature of the tap water and warm water below.

T_{tap}= _______________ T_{warm}=________________ T_{mixed}=______________

Pour the tap water into the warm water and then record the temperature of the mixture.

3 t. **(after testing your thinking)** 20 g of cool water at 20 °C are mixed with 100 g warm water at 60 °C. What is the final temperature of the mixture?
a. less than the mid point temperture
b. at or about the mid point temperature
c. more than the mid point temperature

4p. **(prediction)** 100 g of rocks at 20 °C are mixed with 100 g of warm water at 60 °C. What is the final temperature of the mixture? Hint: Like 20 g of water, 100 g of rocks will change temperature much more for each unit of heat energy gained or lost compared to 100 g of water.
a. less than the mid point temperture (40 °C in this case)
b. at or about the mid point temperature
c. more than the mid point temperature

Test your thinking here. Put 100 g of rocks into an insulated cup and then in another cup put 100 ml of water and heat it up to about 60 °C. Record the temperature of the tap water and warm water below.

T_{rocks}= _____________ T_{warm}=______________ T_{mixed}=______________

Pour the rocks into the warm water and then record the temperature of the mixture.

4t. **(after testing your thinking)** 100 g of rocks at 20 °C are mixed with 100 g warm water at 60 °C. What is the final temperature of the mixture?
a. less than the mid point temperture
b. at or about the mid point temperature
c. more than the mid point temperature

5. Land is somewhat like rocks as far as its specific heat is concerned. Why is the mean annual temperature range (Difference between Mean summer temp. and Mean winter temp.) smaller in the Southern hemisphere than in the northern hemisphere?

6. Explain why the annual temperature range in Vancouver BC is 16 °C while in Winnipeg Manitoba the annual range is 38 °C. (See globe.)

Celsius and Fahrenheit Scales

The conversion between Celsius and Fahrenheit scales are:

$$T_C = \frac{(T_F - 32)}{1.8}$$

$$T_F = 1.8T_C + 32$$

Using these conversions answer the following questions.

70 °F = __________ °C

37 °C = __________ °F

90 °F = __________ °C

-40 °F= __________ °C

Celsius and Kelvin Scales The conversion between Clesisus and Kelvin temperature scales are:

$$\mathbf{T_K = T_C + 273 \quad T_C = T_K - 273}$$

Using these conversions answer the following questions.

20 °C = __________ K

37 °C = __________ K

300 K= ___________ °C

6000 K= ___________ °C

The Kelvin scale is said to be the absolute temperature scale because the Kelvin Temperature is directly proportional to the average energy per molecule. At absolute zero Kelvin, the molecular energy is zero.