Worksheet: Rules for Thermal Phenomena

Name ________________

The goal of this worksheet is for you and your partners to identify a set of "rules" that you can use to explain and predict macroscopic thermal phenomena. Because you've had a lot of experience with thermal phenomena over the course of your lifetime -- and you may even have learned about thermal physics in class -- you already know a lot about these phenomena. Here, we'll be asking you to identify and write down what you already know.

Use the box below to write down your "rules" as you're prompted throughout the worksheet.

Model-building box

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I. OBJECTS OF THE SAME MATERIAL

A. Consider the following scenario: Two identical metal blocks are sitting on a table. One's temperature is 100°C and the other's is 20°C. The blocks are placed in contact with one another and put into an insulated box. After several minutes, the blocks are the same temperature as one another.

i. Why do the two blocks end up at the same temperature? If your answer feels really simple to you -- like, "because it just does" -- try digging a little deeper to articulate why *that* simple thing happens.

ii. Draw an energy tracking diagram that illustrates the process of the two blocks coming to the same temperature. Your diagram should:

- Include "snapshots" of the important instants in time for this scenario.
- Include each object that is relevant
- Show units of energy explicitly, labeling each unit with a letter indicating the type of energy
- Be sure that energy is conserved! The number of energy units should be the same at all instants in your diagram.

iii. How does your energy tracking diagram connect to your explanation for why the two blocks end up at the same temperature? In particular, if you didn't use energy ideas in your answer to part i, connect your thinking there to your analysis of the energy dynamics in part ii.

iv. The final temperature of the blocks is 60°C (halfway between 20 and 80 °C), assuming that no thermal energy is transferred from the blocks to the environment. How do you make sense of this?

v. So far, you've explained why two metal blocks that come into contact with one another become the same temperature, modeled the energy dynamics of that scenario, and made sense of why the final temperature of the blocks is halfway between their initial temperatures. To do all of that, you were drawing on a variety of ideas about thermal phenomena that allowed you to predict or explain what is happening (like "objects tend toward equilibrium" or "hot things tend to get less hot"). **Use the box on page 1 to write down the ideas ("rules") you used to make sense of the scenario you just considered.**

B. Consider the following scenario: You have two cubes made of the same metal that have different mass (and volume). Each cube is heated to 100°C and then placed in identical volumes of room-temperature water in insulated cups. After several minutes, each cube is the same temperature as the water it is immersed in, but the temperature of the water in the two cups is different. The water containing the larger cube has a higher temperature.

i. Why does this happen?

ii. Draw an energy tracking diagram that illustrates your idea.

iii. What rules are you using to explain why this happens? **Write your rules in the box on the first page.**

II. OBJECTS OF DIFFERENT MATERIALS

A. Consider the following scenario: A 100°C cube of iron with mass of 100g is placed into a beaker with 100 ml (100g) of 20°C water. After several minutes, the temperature of the iron and water have stopped changing and both are 28°C.

i. Explain this observation, and include an energy tracking diagram that illustrates this scenario.

ii. What would someone need to know about temperature, thermal energy, and thermal processes to be able to answer this question? **Write these ideas down as rules in the box on the first page.**

B. Consider the following scenario: A 100°C cube of iron with mass of 100g is placed into a beaker with 100g of 20°C olive oil. After several minutes, the temperature of the iron and oil have stopped changing and both are 35°C.

i. Explain this observation, and include an energy tracking diagram that illustrates this scenario.

ii. What rules are you using to explain why this happens? **Write your rules in the box on the first page.**

III. REVIEWING YOUR RULES

At this point, you should have a preliminary set of rules written down in your box.

Take a moment to **review your preliminary set** by making your statements more precise, or by combining rules that may be special cases of a broader thing. (For example, if we were talking about forces and had written down, “Gravity changes the motion of objects,” and, “Friction changes the motion of objects,” we could combine those to say, “Forces change the motion of objects.”)

Compare what’s in your rule box with what’s in your partners’ rule boxes. (We know you’ve been working with them all along, but compare what you have actually written down.)

A. Do they have anything written down that you don’t? If so, do you want to add what they have? Why or why not?

b.

c.

B. Did they word any of the same rules differently? If so, what's different about the wording, and are those differences meaningful, physics-wise, or just stylistic?

C. Do you have any unanswered questions about your rules or about what happens in the three scenarios above? **Record them in the rule box on the first page.**

CONCLUSION

You now have a refined (but still preliminary) set of rules for explaining and predicting thermal phenomena. When rules like these hold up again and again under experimental conditions, or when we can use existing rules or theoretical tools to verify them, they become part of a *model* for thermal phenomena. Most of the time, especially as we (and you) are learning about phenomena for the first time (or even the second or third), our models are *incomplete;* that's a sign that learning is happening! So identifying that what's in your box can't predict new things fully is a signal that you are still learning, which is exactly the right thing. For now, let's call what's in your box a preliminary, incomplete model for thermal phenomena that *you* can test or refine as you continue through your course.