

THERMODYNAMICS DRAFT RULES 17

1. DESCRIPTION: Teams must construct an insulated device prior to the tournament that is designed to retain heat and complete a written test on thermodynamic concepts.

A TEAM OF UP TO: 2 EYE PROTECTION: C IMPOUND: Yes APPROX. TIME: 50mins.

2. EVENT PARAMETERS:

- a. Each team may bring one three-ring binder of any size containing information in any form and from any source, attached using the provided ring(s). The information may be removed during the event. Sheet protectors and laminated sheets are allowed.
- b. Teams must impound: Their insulating device; 2 identical, unaltered, glass or plastic, standard (height ~1.4 times the diameter) 250mL beakers; and copies of graphs and/or tables for scoring.
- c. Teams do not impound tools, supplies, writing utensils, or two dedicated calculators of any type for use during any part of the event.
- d. Event supervisors will supply the hot water, devices for transferring measured volumes from the water source to the team's beakers, ice water, thermometers, or probes (recommended). Non-contact thermometers are allowed.
- e. Prior to the competition, teams must calibrate their devices by preparing graphs and/or tables showing the relationship between elapsed cooling time and ending water temperature for various quantities of water and starting water temperatures.
 - i. Any number of graphs and/or data tables may be submitted but the team must indicate up to four to be used for the Chart Score, otherwise the first four provided are scored.
 - ii. Graphs and/or tables may be computer generated or drawn by hand on graph paper. Each must be on a separate sheet of paper. A template is available on www.soinc.org.
 - iii. Teams are encouraged to have a duplicate set to use, as those submitted may not be returned/
- f. Participants must wear eye protection during Part I. Teams without proper eye protection must be immediately informed and given a chance to obtain eye protection if time allows.
- g. Participants must be able to answer questions regarding the design, construction, and operation of the device per the Building Policy found on www.soinc.org and may be penalized per the policy.

3. CONSTRUCTION:

- a. Devices may be constructed of and contain any materials except for the following prohibited materials: asbestos, mineral wool, fiberglass.
- b. For Division B, the device must fit within a 20.0cm x 20.0 cm x 20.0 cm cube. For division C, the device must fit within a 15.0cm x 15.0cm x15.0 cm cube.
- c. Within the device, participants must be able to insert and remove a beaker that they supply (see 2b).
- d. The device must also easily accommodate the insertion and removal of a thermometer/probe into the beaker via a hole at least 1.5 cm in diameter all the way through directly above the beaker. The top surface of the hole must be less than 12 cm above the inside bottom surface of the beaker. The whole must remain open and unobstructed during the competition.
- e. Devices will be inspected to ensure that there are no energy sources (e.g., no electrical components, small battery powered heaters, chemical reactions, etc.) to help keep the water warm. At the event supervisor's discretion, teams must disassemble their device at the end of the testing period in order to verify the material used in construction.
- f. All parts of the device must not be significantly different from room temperature at impound

4. THE COMPETITION:

Part 1: Device Testing

- a. At the start of each competition block, the event supervisors must announce the temperature of the source water bath (60° to 90° C), the volume of the water to be used (50 to 150 mL in 25 mL increments at Regional competitions, 10mL at State competitions, and 1 mL at National competitions) and the amount of cooling time allowed (20 to 40 minutes). These variables will be the same for all teams.
- b. The event supervisor will announce the current room temperature.
- c. Teams will be given 5 minutes to setup/modify their devices at the start of the competition block and use their graphs/tables to begin room temperature prediction calculations. Devices that do not meet the construction specs will not be allowed to be tested until brought into spec.
- d. Each team, in a staggered sequence, must have the set amount of water poured into each of their 2 beakers, one of which they must then insert into their device, the other must be placed on an open surface next to the device. Nothing must be placed under or immediately around the external beaker. Teams may secure and/or close access panels with fastening materials after inserting the beaker. Event supervisors must record the time each team receives their water. Teams may utilize their own thermometers to measure the starting water temperature in their beakers.
- e. Teams may elect to add up to 50 mL of water from an ice bath to their internal beaker immediately after receiving the hot water for bonus points. Each team may choose their own volume.
- f. Teams must use their graphs and/or tables to calculate the temperature of the water in their beaker at the end of the cooling time. They must provide the event supervisors with their estimate prior to the beginning part II.
- g. At the end of the cooling period, the event supervisor will record the temperature in each beaker to the best precision of the available instrument. Supervisor may leave thermometers/probes in the devices and the un-insulated beakers for the entire cooling period, but will announce if they will do so before impound. Otherwise they will first insert a thermometer/probe into the un-insulated beaker, wait at least 20 seconds, and record the resulting temperature. The event supervisor will then wipe any residual water off the thermometer/probe and repeat the same process with the beaker inside of the participant's device. Multiple thermometers/probes may be used at the supervisor's discretion.
- h. The supervisor will review with the team the Part I data recorded on their score sheet.
- i. Teams filing an appeal regarding Part I must leave their device in the competition area.

Part II: Written Test

- j. Teams will take a test on thermodynamic concepts during the remaining time after all devices have been loaded with water. All teams will have the same amount of time to take the test.
- k. Unless otherwise requested, answers must be in metric units with appropriate significant figures.
- l. Teams must be given a minimum of 20 minutes to complete a written test.
- m. Questions may be multiple choice, true-false, completion, or calculation problems.
- n. The competition must consist of at least five questions from each of the following areas:
 - i. Temperature scales and conversions, definitions or heat units.
 - ii. Thermal conductivity, heat capacity, specific heat, latent heat, phases of matter, entropy, enthalpy
 - iii. Thermodynamic laws and processes (e.g. Carnot cycle and efficiency, adiabatic, isothermal)
 - iv. The history of thermodynamics

5. SCORING:

- a. High score wins.

- b. All scoring calculations are to be done in degrees Celsius.
- c. One of the submitted graphs and/or tables selected by the event supervisor, must be scored as follows for the Chart Score. Partial credit may be given
 - i. 2 points for including data spanning at least one variable range listed in 4.a
 - ii. 2 points for including at least 10 data points
 - iii. 2 points for proper labeling (e.g. title, team name, units).
 - iv. 1 point for each graph or table turned in (up to 4 total, as long as they are not the same)
- d. The final score = TS + CS + HS + PS + Bonus; a scoring spreadsheet is at www.soinc.org:
 - i. Test Score (TS) = Part II score/ Highest Part II score for all teams) x 45 points
 - ii. Chart Score (CS)= max of 10 points
 - iii. Heat Retention Factor (HRF) = (internal beaker water temp /external beaker water temp) The Heat Score (HS) = (HRF/Highest HRF of all teams) x15 points
 - iv. Prediction Estimate (PE) = (1-(abs(final internal beaker water temp – predicted internal beaker water temp)/final internal beaker water temp)). The Prediction Score (PS) = (PE/Highest PE of all teams) x 25 points.
 - v. Ice Water Bonus = (volume of ice water in mL/10 points)
- e. Teams that are disqualified for unsafe operation or that do not bring an insulating device receive a CS, HS, PS, and Bonus of 0. Teams will be allowed to compete in Part II.
- f. The HRF, PE and Bonus must be multiplied by 0.7 when calculating scores if any construction violation(s) are corrected during Part I testing period or if the team misses impound.
- g. The HRF PE, and Bonus must be multiplied by 0.9 when calculating the scores if the team violates any of the rules in THE COMPETITION.
- h. Tie Breakers: 1st – Best TS ; 2nd – Best HS ; 3rd – Best PS ; 4th Best Bonus