Tutorial Section: ☐ First Letter of Last Name: ☐

Physics 157 Midterm 1

The University of British Columbia

October 9, 2019 TIME: 1.0 hour

CANDIDATE'S NAME: ____________________ ____________________________

Last Name First Name or Initials

Please place your UBC Student card on your desk.

SIGNATURE: ______________________________

STUDENT NUMBER: ________________________

THIS EXAMINATION CONSISTS OF 5 MULTIPLE CHOICE QUESTIONS AND TWO LONG ANSWER QUESTIONS FOR A TOTAL OF 8 PAGES. CHECK TO ENSURE THAT THIS PAPER IS COMPLETE.

TO OBTAIN FULL CREDIT FOR LONG ANSWER QUESTIONS, YOU MUST SHOW YOUR WORK AND EXPLAIN YOUR ANSWER.

INSTRUCTOR'S NAME: (circle one) 101–Van Raamsdonk 102–Dierker 103–Zhou

Read and observe the following additional rules: No candidate shall be permitted to enter the examination room after the expiration of one-half hour, or leave during the first half-hour of the examination. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.

CAUTION: Candidates guilty of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:

(a) Making use of any books, memoranda, cell phones, audio or visual players or other memory aid devices and electronics, other than authorized by the examiners.

(b) Speaking or communicating with other candidates.

Any calculator is allowed; memory must be cleared.

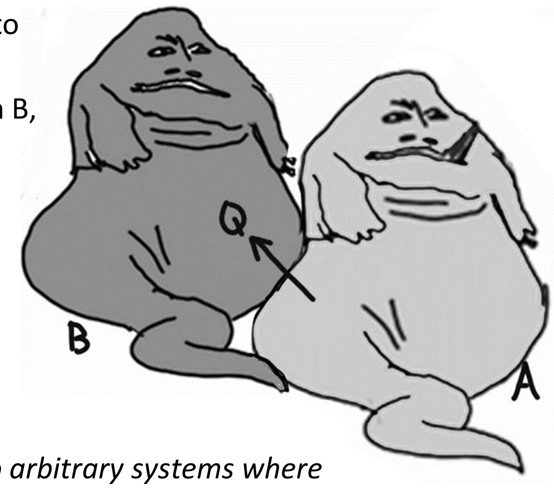
Each Question is worth the points indicated below:

Multiple choice (Q1-Q5): __________	Q6: ___________	Q7: ____________
/10	/10	/10

Total: /30

Multiple choice (2 points each). Write your answers in the boxes on the next page.

Question 1: Two systems (each initially in equilibrium) are put into thermal contact and the pair is thermally insulated from its environment. If heat is observed to flow from system A to system B, which of the following is always true?



A) System A initially had more energy than system B.

B) System A initially had a higher temperature than system B.

C) Both A and B are true.

D) Neither A nor B can be concluded from the question.

Note: *the picture is only an example; your answer should apply to arbitrary systems where A and B are not necessarily similar.*

Question 2: A mass **m** of steam at 120°C is sealed in a metal container whose walls are initially at 40°C. If the final equilibrium temperature of the system is 80°C, which of the following represents Q_{steam}, the net heat added to the steam during the process (i.e. heat added minus heat lost)?

A) $m\, c_{steam}\, (-40^oC)$

B) $m\, c_{steam}\, (-20^oC) + m\, c_{water}\, (-20^oC)$

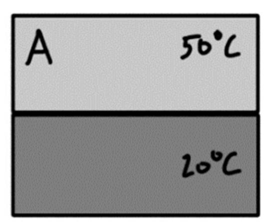
C) $m\, c_{steam}\, (-20^oC) + m\, L_v + m\, c_{water}\, (-20^oC)$

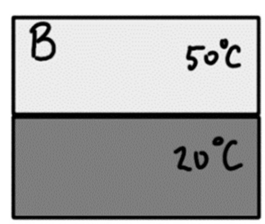
D) $m\, c_{steam}\, (-20^oC) - m\, L_v + m\, c_{water}\, (-20^oC)$

E) $m\, c_{steam}\, (-40^oC) + m\, L_v$

F) $m\, c_{steam}\, (-40^oC) - m\, L_v$

Question 3: In the picture, objects A and B with the same mass are initially at temperature 50°C. These are placed on a pair of identical objects with initial temperature 20°C. It is found that A ends up with a lower final temperature than B. From this we can conclude that





A) A has a higher heat capacity than B

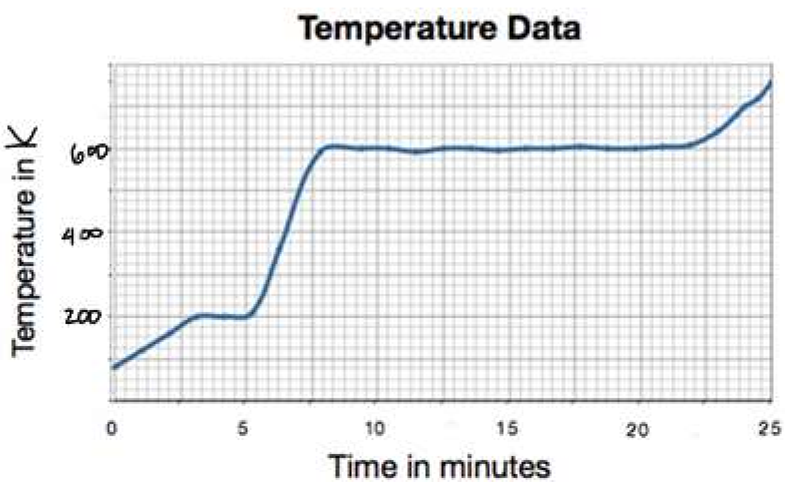
B) A has a lower heat capacity than B

C) A has a higher thermal conductivity than B

D) A has a lower thermal conductivity than B

E) None of the above can be concluded with certainty

Assume that no heat is exchanged with the environment.



Question 4: The graph shows the temperature vs time for a certain material that is heated at constant power, starting from when it is in its solid phase. The ratio between specific heat of the liquid phase and the specific heat of the solid phase is closest to

A) 1/6 B) 1/4 C) 1 D) 4 E) 6

Question 5: A liquid with volume 0.999L and thermal expansion coefficient $\beta = 20\times10^{-5}\ K^{-1}$ sits in an open container of volume 1L and thermal expansion coefficient $\alpha = 3\times10^{-5}\ K^{-1}$. If we now change the temperature of the system, which equation below gives the change in temperature after which the liquid will precisely fill the container?

A) $(20\times10^{-5}\ K^{-1})\ \Delta T = 0.001$

B) $(17\times10^{-5}\ K^{-1})\ \Delta T = 0.001$

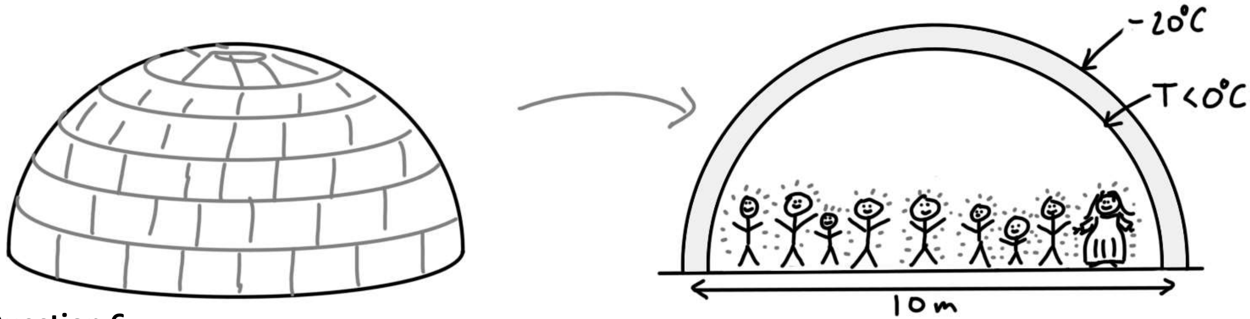
C) $(17\times10^{-5}\ K^{-1})\ \Delta T = -0.001$

D) $(11\times10^{-5}\ K^{-1})\ \Delta T = 0.001$

E) $(11\times10^{-5}\ K^{-1})\ \Delta T = -0.001$

Write your multiple choice answers here:

1	2	3	4	5



Question 6

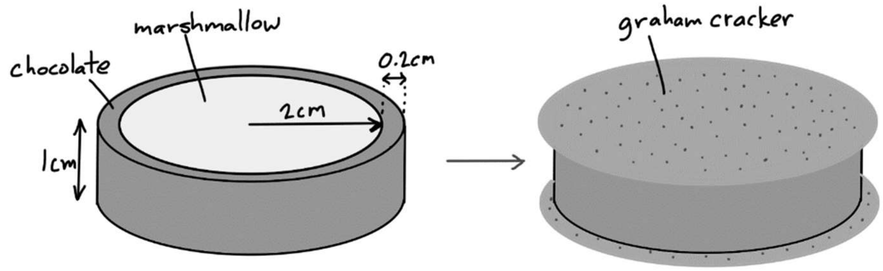
a) Imwë, Princess of Frozenia, is planning to hold her wedding in a large hemispherical igloo of diameter 10m with ice walls of thickness 0.5m. She expects an outside air temperature of -20^{o}C. If Frozenian people each typically produce heat at a rate of 100W, what is the maximum number of people that can be at Imwë's wedding (including herself) to ensure that the inside walls of the igloo remain below 0^{o}C so they don't melt?

For the purposes of calculating the area of the walls, you may ignore the difference in area between inside and outside and use diameter 10m.

Assume that the floor of the igloo is well-insulated so that no net heat flows through it. We have that k_{ice} = 1.592 W/m·K, ρ_{water} = 1000kg/m^3, ρ_{ice} = 920kg/m^3, c_{ice} = 2100 J/kg·K, L_f =334×10^{3}J/kg

b) Princess Imwë invites the maximum number of guests to her wedding according to part a, and all the invited guests show up. However, her cousin Allwë decides to bring her boyfriend Doug, whom she's barely just met and who wasn't invited. If Doug also produces heat at a rate of 100W, and if the wedding lasts an hour, what volume of water melts from the inside walls of the igloo?

Note: the thickness of the walls don't change significantly during this time. Assume the inner wall is already at 0^{o}C *when the wedding begins.*

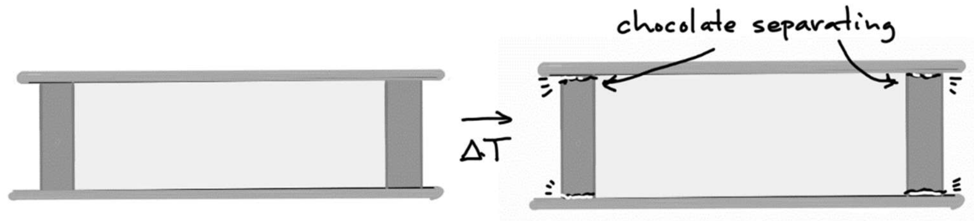


Question 7

In your first assignment as Chief Dessert Engineer for the United Cookie Corporation, you design a cookie whose interior is a layer of marshmallow surrounded by a ring of chocolate. The top and bottom are round graham crackers, to which the marshmallow and chocolate are attached securely.

a) In the first stage of the manufacturing process, the marshmallow (mass 20g, c =1200 J/kg·K) is surrounded by the layer of chocolate (mass 10g, c =2000 J/kg·K), initially at 35°C. What should the initial temperature of the marshmallow be if you would like the final temperature of the marshmallow-chocolate layer to be 10°C once equilibrium is reached (before the graham cracker is attached)? (**5 points**)

Assume the marshmallow and chocolate don't exchange heat with their surroundings during this process.



b) After the graham crackers are attached, and the entire cookie is in equilibrium at 10°C, there is no stress in the marshmallow or chocolate. The chocolate will separate from the graham cracker if the (vertical) tensile stress in the chocolate exceeds 1.3×10^3 *Pa*. What is the maximum temperature increase the cookies can withstand without the chocolate separating?

Marshmallow: $Y = 1.0 \times 10^4$ Pa, $\alpha = 0.0025K^{-1}$ *Chocolate: $Y = 1.5 \times 10^5$ Pa and $\alpha = 0.0010K^{-1}$*
Assume the graham cracker does not bend and ignore effects related to expansion in the horizontal directions. ***(5 points)***

Possibly useful formulae:

$$
\begin{aligned}
T_K &= T_C + 273.15 \\
\Delta L_{th} &= \alpha L \Delta T \\
\Delta V &= \beta V \Delta T \\
\frac{\Delta F}{A} &= Y \frac{\Delta L_{st}}{L} \\
Q &= mc\Delta T \\
Q &= mL \\
H &= kA\frac{T_H - T_C}{L} \\
R &= \frac{L}{k} \\
A &= \pi R^2 \qquad A = 4\pi R^2
\end{aligned}
$$