Specific Heat and Calorimetry; Heat engine overview

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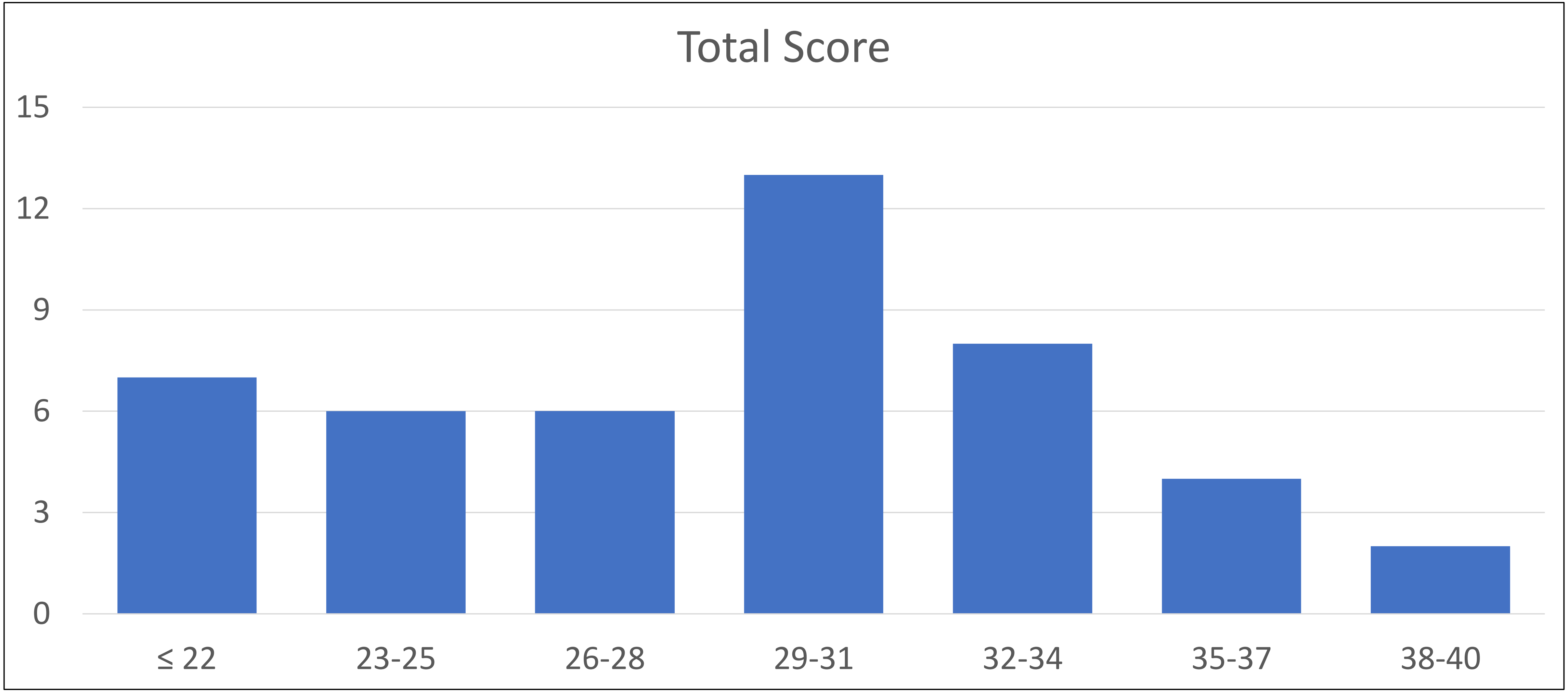
Announcements/Reminders

- Homework 10 will be posted by the end of today, and due next Wednesday (Dec 11)
- We will have our final lab this week
- Midterm 2 solutions and statistics are now posted
- I will give you more information about the final exam in the coming days. Stay tuned!

Comments on midterm 2 (1/2)



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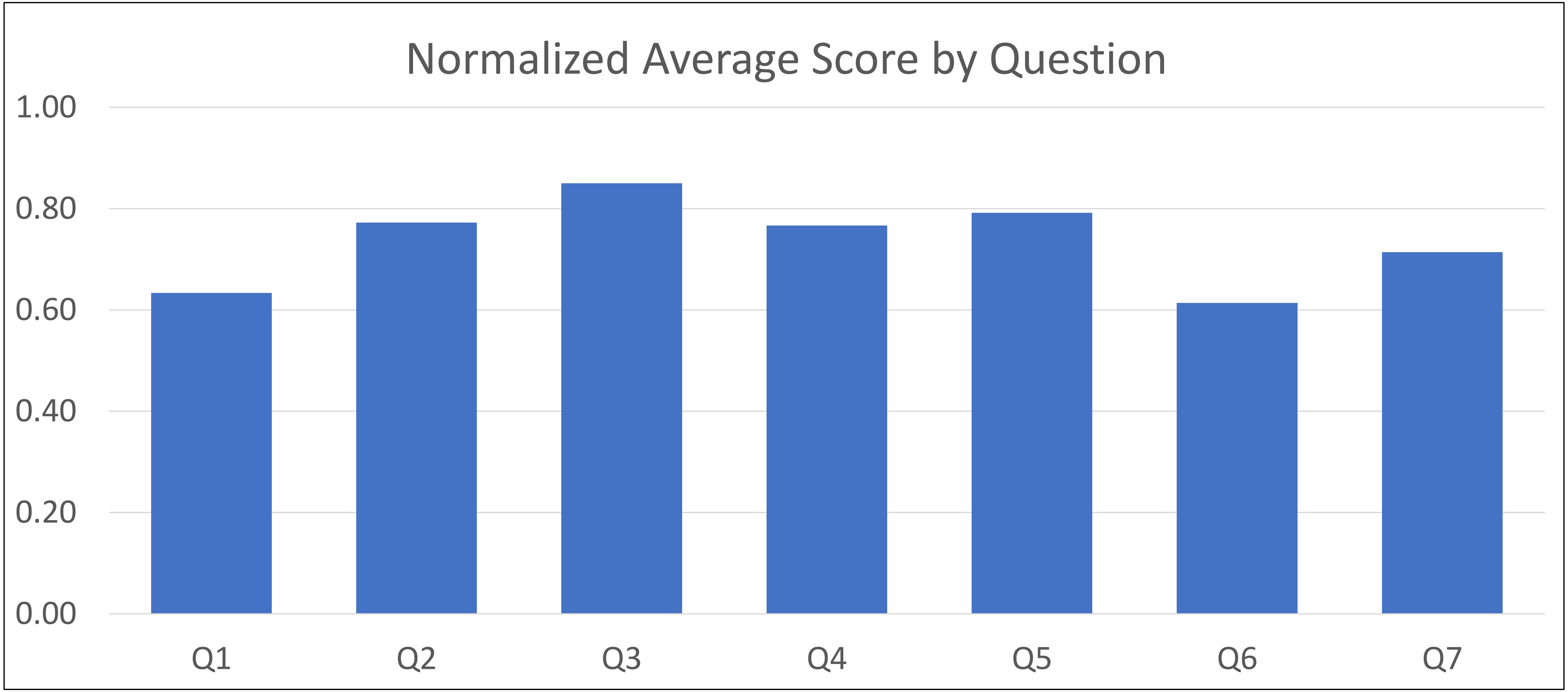


Outline

1. Specific heat and calorimetry
2. ~~Specific heat of ideal gas~~
3. ~~(?) Heat engine overview~~

1. Specific heat and calorimetry

Specific heat and molar specific heat

- The heat it takes to raise the temperature of 1 kg of a given substance by 1 K is called the **specific heat** c of that substance. In equation:

$$Q = Mc\Delta T$$

- Similarly, the heat it takes to raise the temperature of 1 mole of a substance by 1 K is its **molar specific heat** C. In equation:

$$Q = nC\Delta T$$

Specific heat: units and conventions

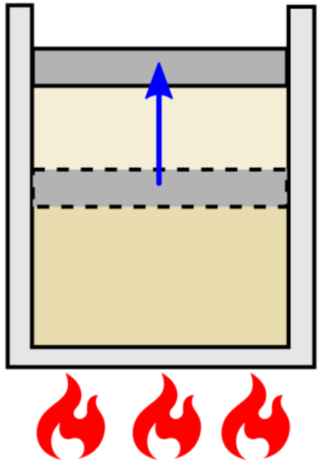
- The SI unit for specific heat is J/kg·K
- The SI unit for molar specific heat is J/mol·K
- Since specific heat is concerned only with change in temperature, there is no real difference between measurement in °C and K

Specific heat and thermal energy

- Since **solids** and **liquids** are essentially incompressible, we may assume $W = 0$ when they are heated or cooled. By the first law of thermodynamics, we thus have:

$$\Delta E_{\text{th}} = Q = Mc\Delta T$$

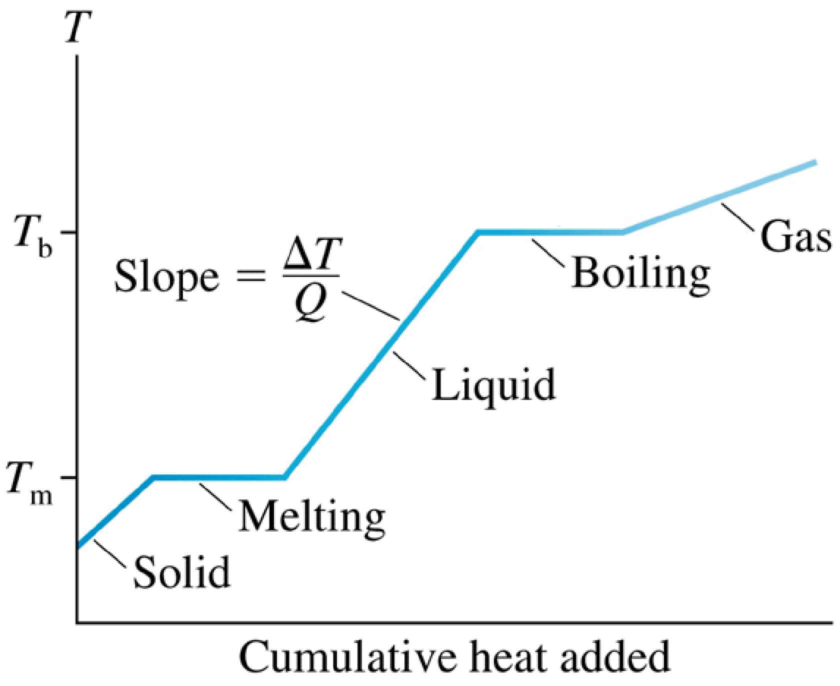
- In contrast, a gas expands when heated under constant pressure, which turns out to contribute $W < 0$. As a result, we generally have $c_P > c_V$ in a gas

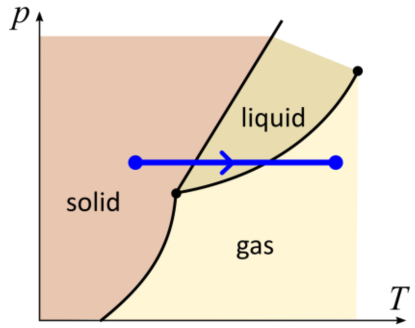


Heat of transformation

- When a substance is undergoing phase change, additional energy is needed to reorganize its microscopic structure
- The **heat of transformation** L is the additional heat needed for this process for each 1 kg of the substance. In equation:

$$Q = ML$$





Heat of transformation: signs and conventions

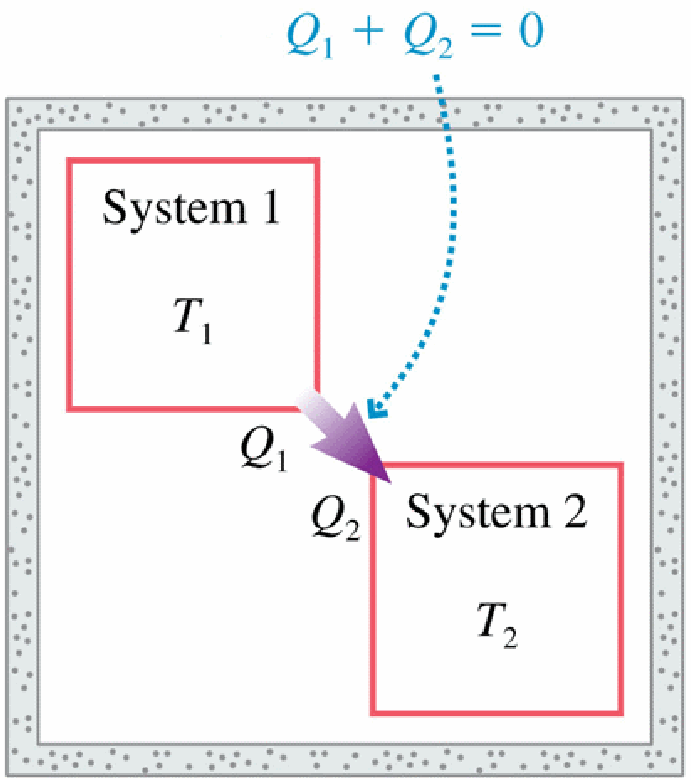
- Heat of transformation is also known as **latent heat**
- The SI unit for heat of transformation is is J/kg
- In general, L is different for different phase change. Also, note the sign reverse between heating and cooling. Thus,

$$Q = \pm ML_f \qquad \text{(+ melt / − freeze)}$$

$$Q = \pm ML_v \qquad \text{(+ boil / − condense)}$$

Calorimetry

- When two objects are in thermal contact with each other but isolated from everything else, we must have $|Q_1| = |Q_2|$
- Regardless of the initial temperatures, when thermal equilibrium is reached we must have $T_1 = T_2$



Your turn: heat capacity and heat exchange

Two objects A and B are brought into thermal contact with each other but are otherwise well-isolated from the surrounding. If $c_{\mathrm{A}} = 900$ J/kg·K while $c_{\mathrm{B}} = 1800$ J/kg·K, the final (equilibrium) temperature is:

A. $\boxed{T_f < 50°\mathrm{C}}$

B. $T_f = 50°\mathrm{C}$

C. $T_f > 50°\mathrm{C}$

$$|Q_A| = |Q_B|$$

$$M_A c_A > M_B c_B$$

$$\Rightarrow \quad |\Delta T_A| < |\Delta T_B|$$