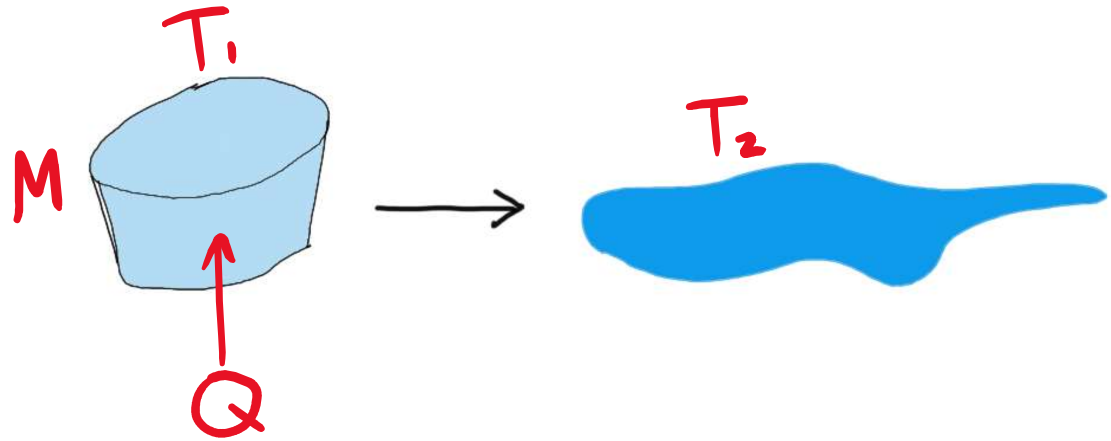


A mass M of ice at temperature $T_1 < 0$ is heated until we have water at temperature $T_2 > 0$. How much heat has been added?

A) $M\, c_{ice} (T_2 - T_1)$

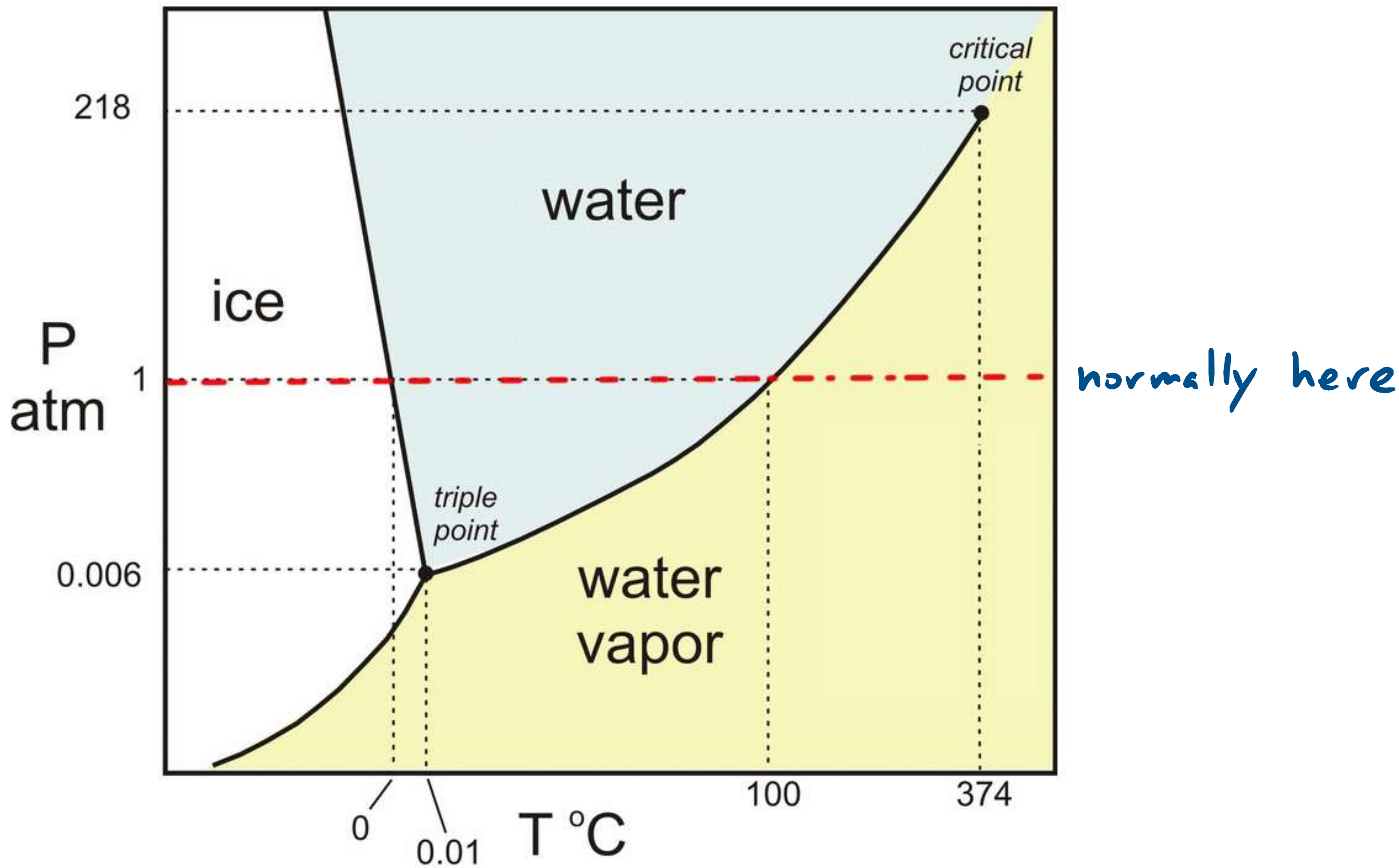
B) $M\, c_{water} (T_2 - T_1)$

C) $M\, L_f$

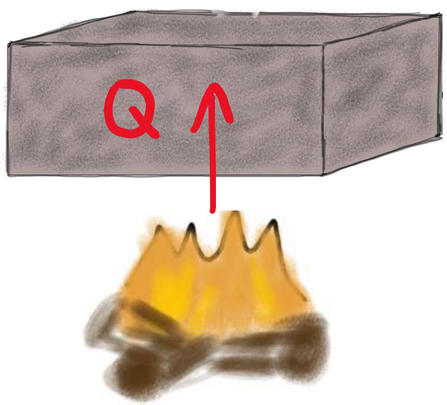
D) $M\, c_{ice} (-T_1) + M\, c_{water} (T_2)$

E) $M\, c_{ice} (-T_1) + M\, L_f + M\, c_{water} (T_2)$

PHASE DIAGRAM: displays phases and phase transition curves as a function of T and P



Heat required to raise the temperature of a material determined by its SPECIFIC HEAT c :



heat added

mass

$$Q = m\,c\,\Delta T$$

OR:

$$Q = n\,C\,\Delta T$$

moles

MOLAR SPECIFIC HEAT

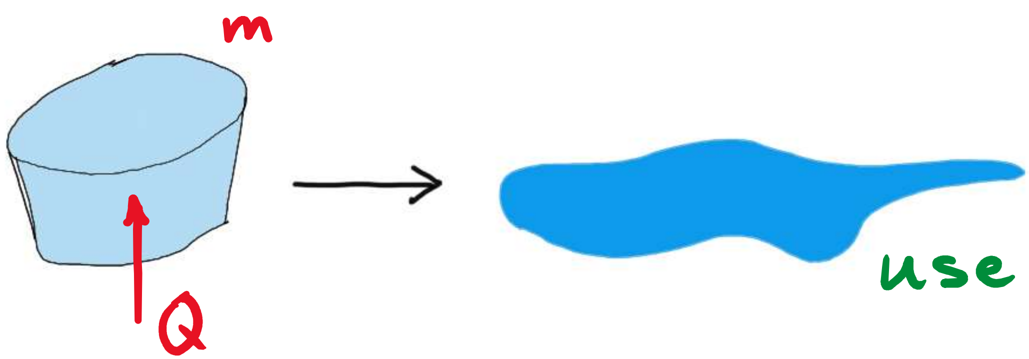
= MOLAR HEAT CAPACITY

LATENT HEAT: Heat required to melt/boil a mass m of material (at melting/boiling point) is:

$$Q = mL$$

mass

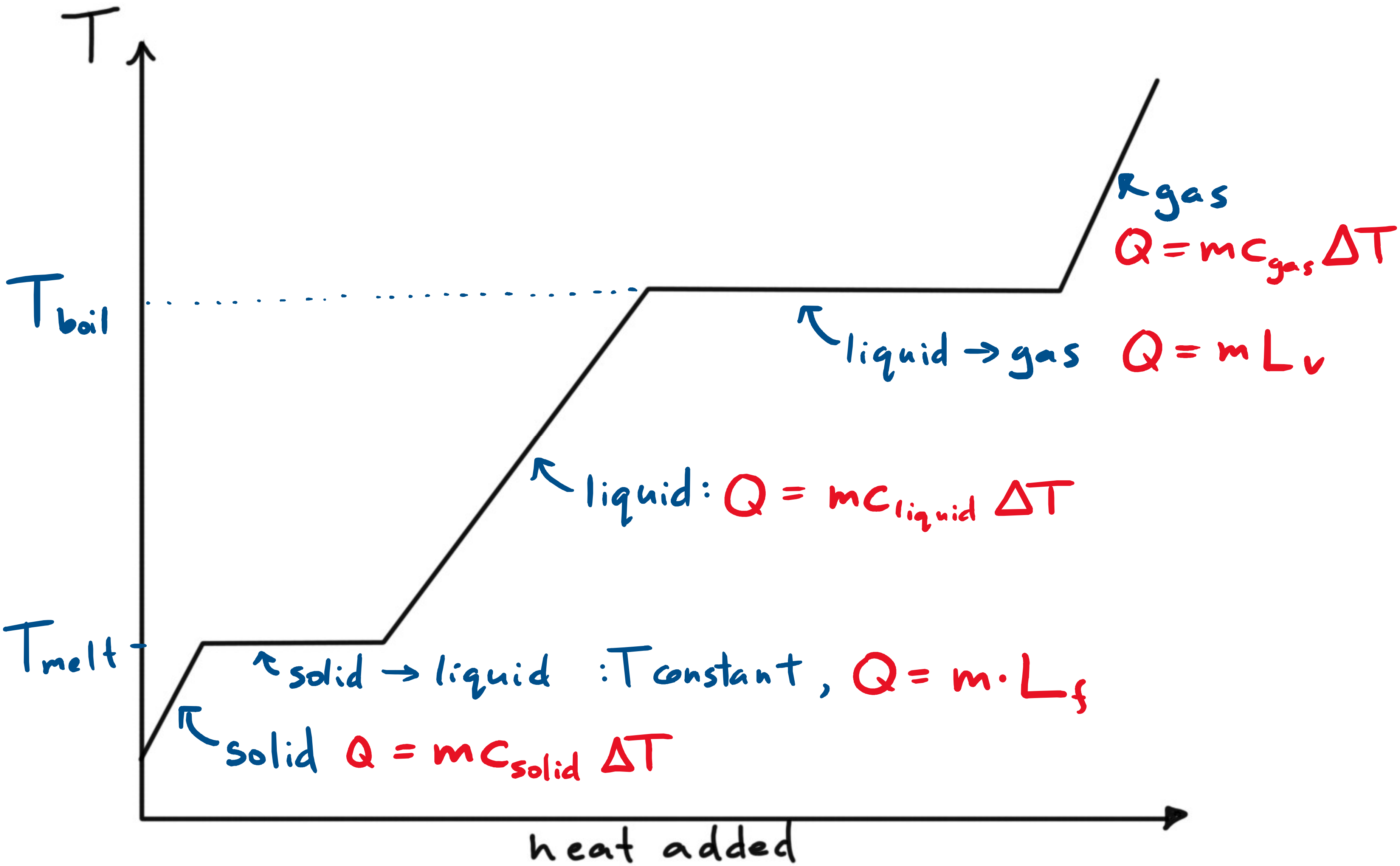
latent heat

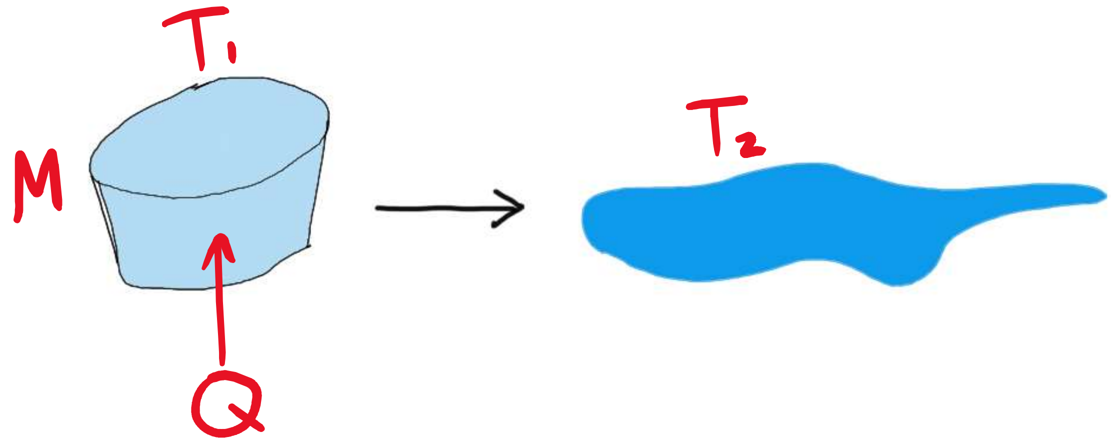


use L_f for melting/freezing

L_v for boiling/condensing

T vs heat added (e.g. water at atmospheric pressure)





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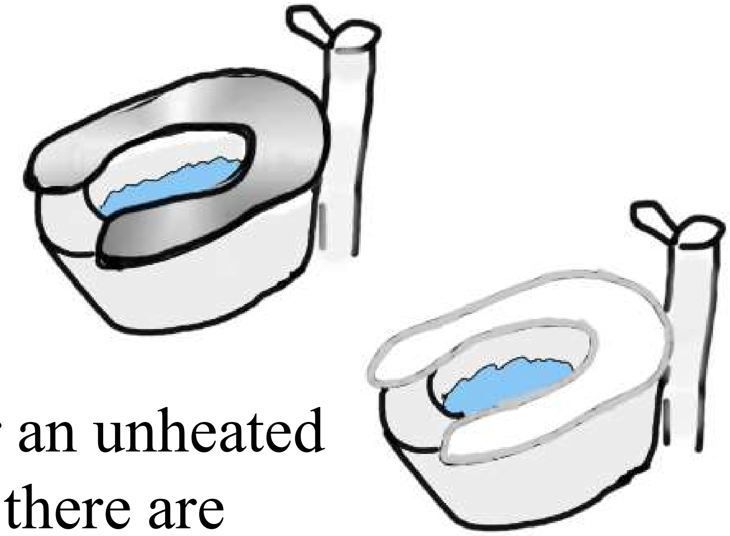
E) $M\,c_{ice}\,(-T_1) + M\,L_f + M\,c_{water}\,(T_2)$

Q to heat ice from T_1 to 0°C

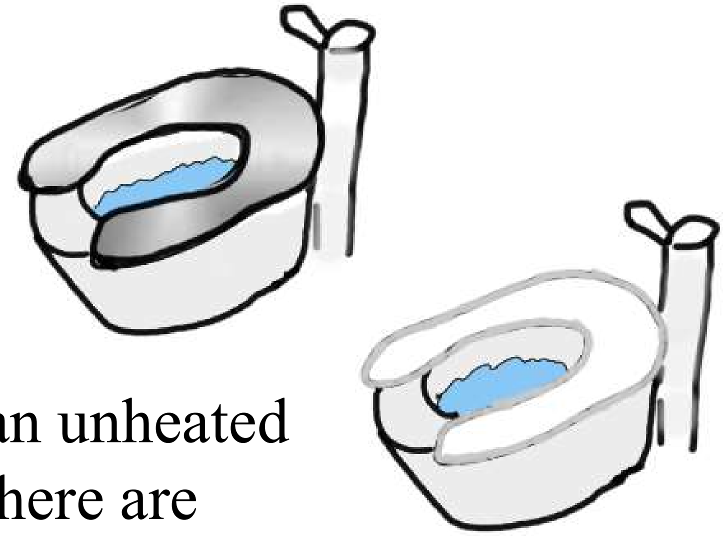
Q to melt

Q to heat from 0°C water to T_2



During a break from skiing, you enter an unheated washroom building (0ºC). You notice there are two toilets, one with a metal seat (c ~ 200 J/kg·K) and one with a plastic seat (c ~ 1600 J/kg·K). Assuming that you need to sit down, and that both seats are clean, which do you choose?

A) The metal seat.
B) The plastic seat.
C) It doesn't matter: they are the same temperature.
D) My head says A) but my heart says B).



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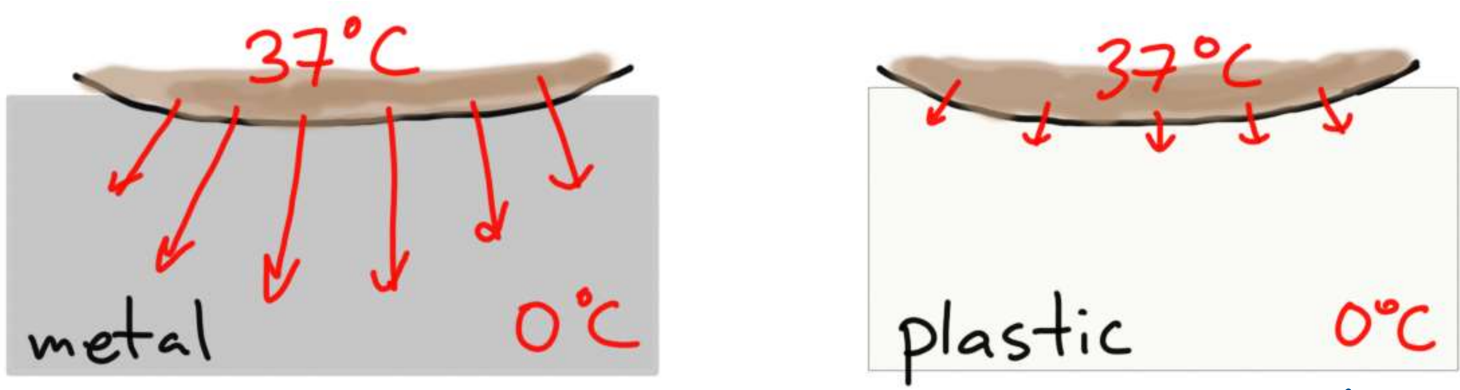
D) My head says A) but my heart says B).

I'm not here to give you advice about using the bathroom, but personally, I would go for the plastic one.

THERMAL CONDUCTIVITY: Heat moves more quickly through some materials than others in response to a temperature gradient.

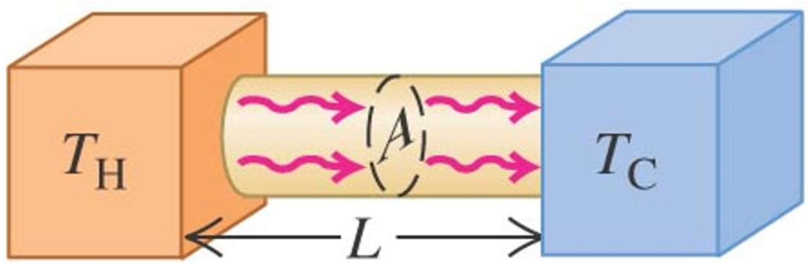


good thermal conductor

poor thermal conductor (insulator)

- the metal feels colder since it cools our skin quicker

THERMAL CONDUCTIVITY: Determines heat current from temperature gradient.



cross sectional area

$$H = kA \underbrace{\frac{T_H - T_C}{L}}_{\text{temperature gradient}}$$

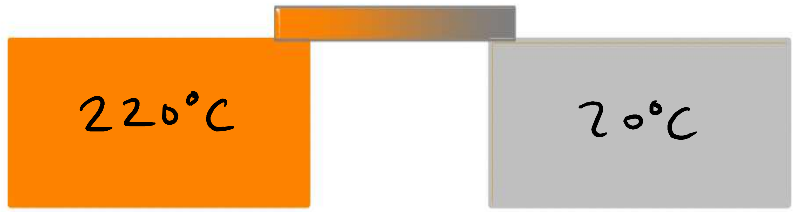
temperature gradient

calculus version: $\frac{dT}{dx}$

Heat current (Joules/second)

Thermal conductivity = basic property of a material

Conductivity worksheet



A block of aluminum at room temperature (T_1 = 20℃) is connected to another equivalent block of aluminum at (T_2 = 220℃) by another strip of aluminum (that has been in place for a while).

Sketch graphs (one for each block) showing how you expect the temperatures of the two blocks to behave as a function of time.

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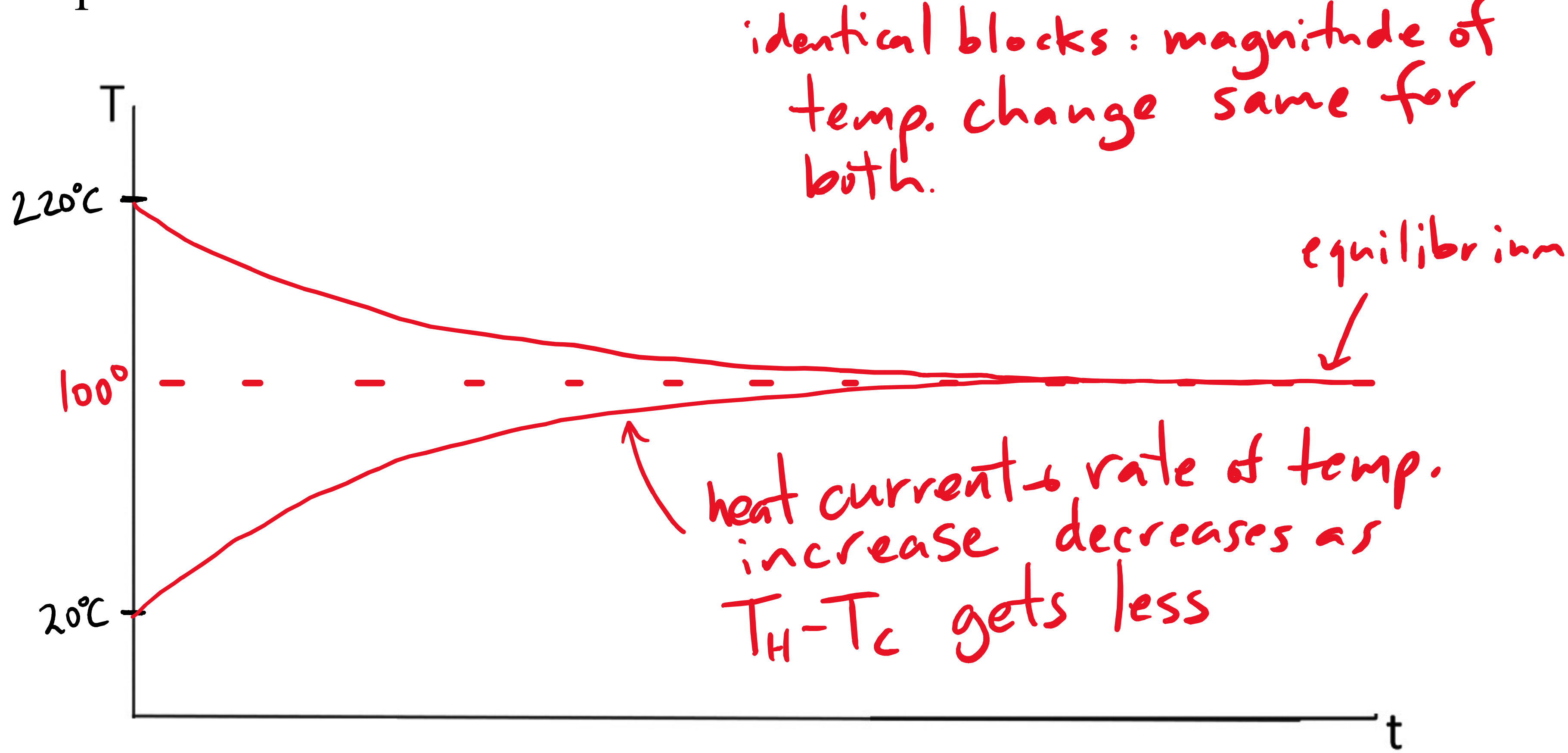
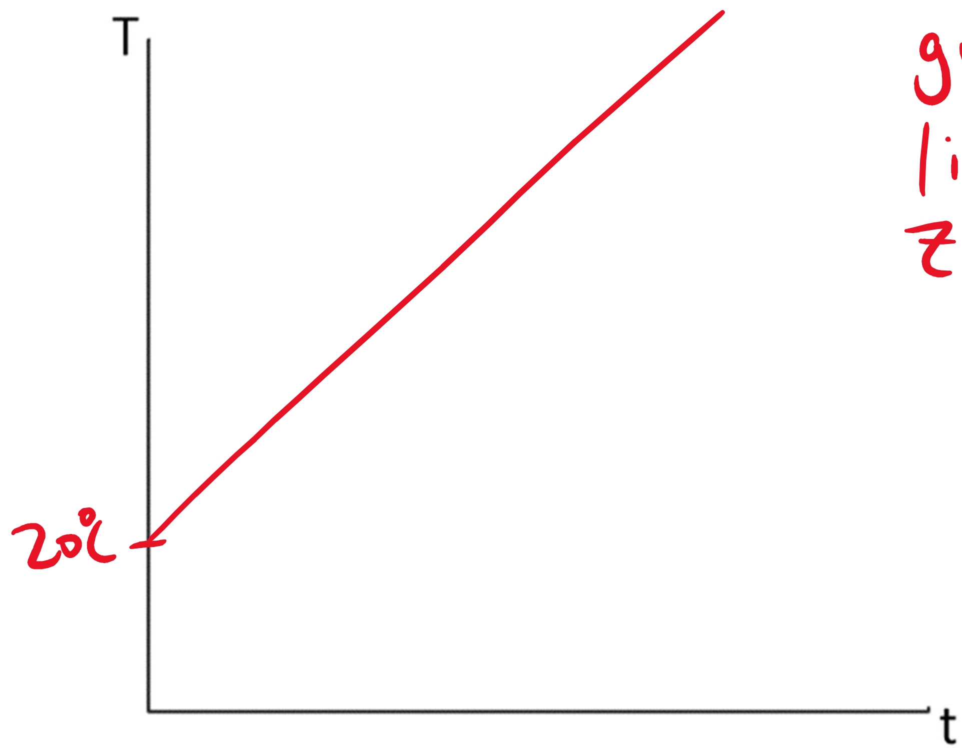
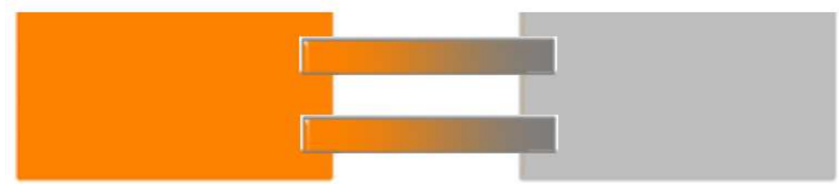


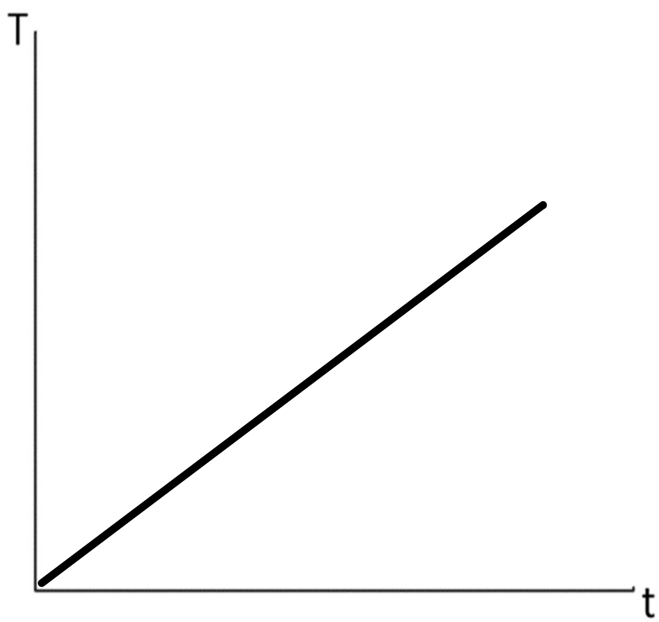
Sketch a graph of how the temperature behaves as a function of time at early times (remembering that the two blocks have already been connected for a while).

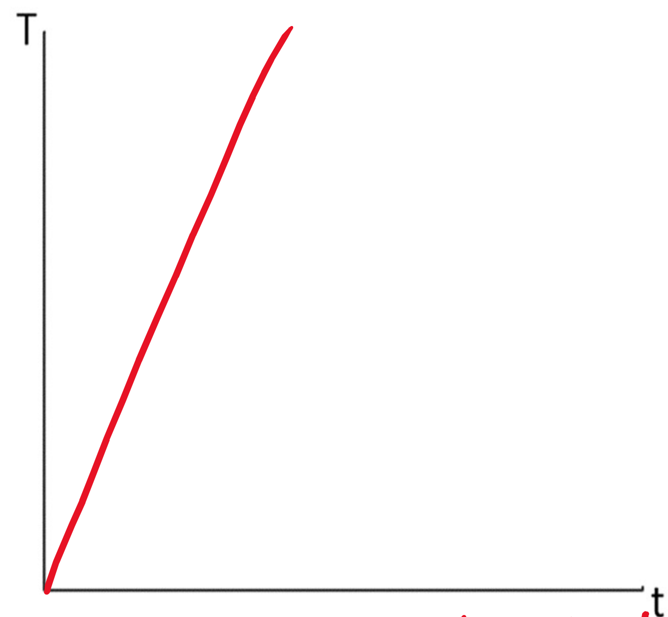
any smooth graph looks linear if we zoom in enough



VS



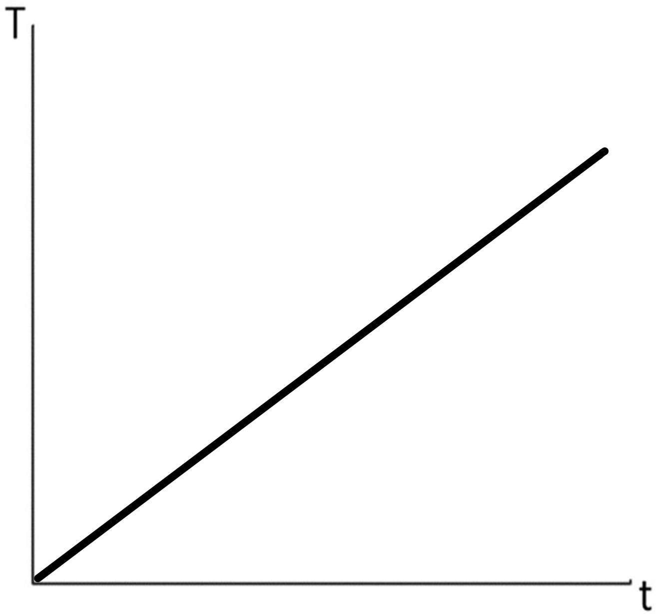


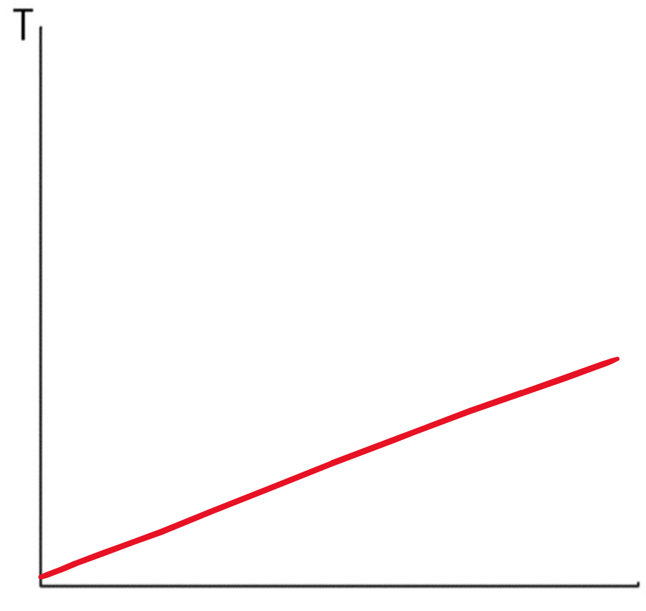


$$\boxed{H = kA\frac{T_H - T_C}{L}}$$

A is double here so larger heat current + faster heating

vs



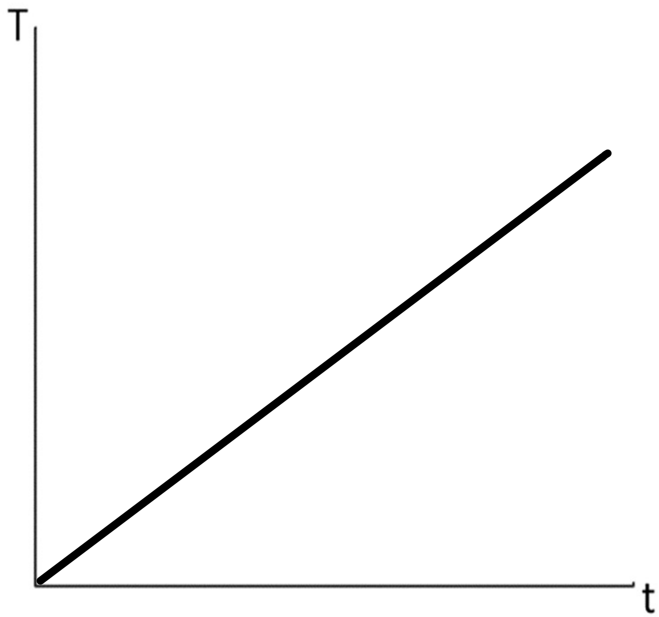


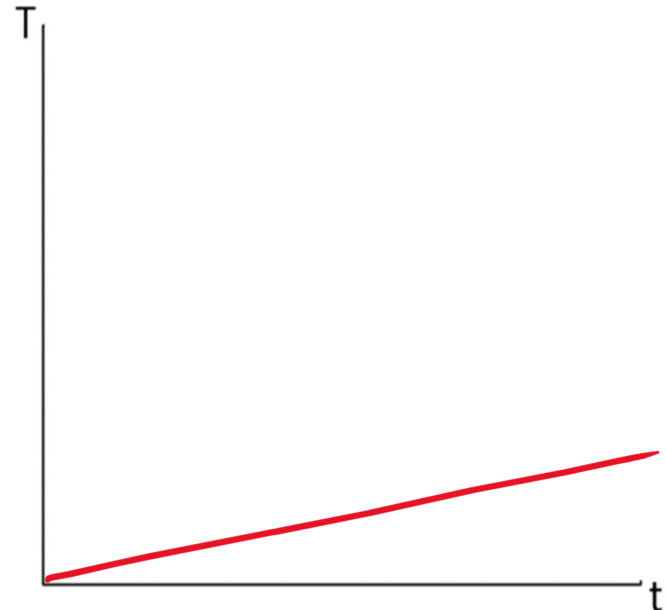
$$\boxed{H = k A \frac{T_H - T_C}{L}}$$

L is double here so smaller heat current and slower heating

vs

$k_{steel} \approx \frac{1}{4} k_{aluminum}$

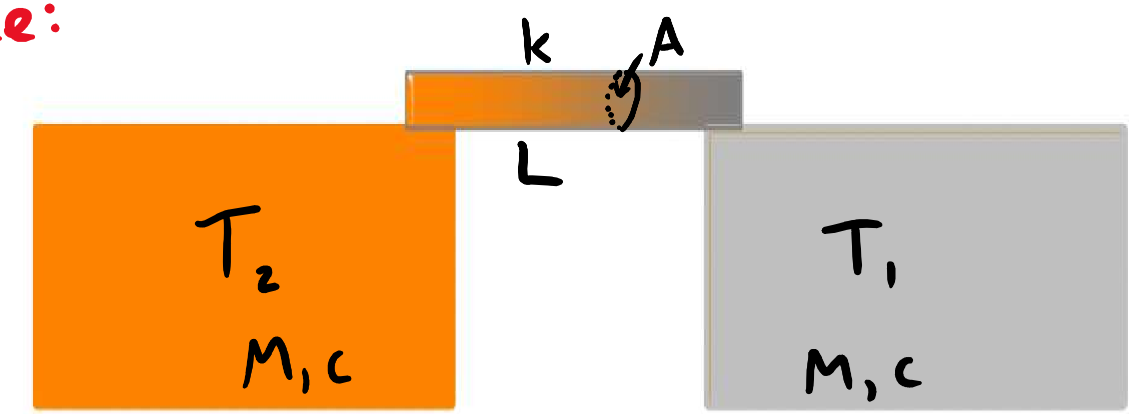




$$\boxed{H = k A \frac{T_H - T_C}{L}}$$

k_s is $\frac{1}{4} k_{al.}$ so H will be 4x smaller and heating will be slower

Next time:



What is the change in temperature dT of the cooler block that occurs in a small time dt?

Hint: What is the meaning of H in the conductivity formula? In terms of H, how much heat is added to this block in the time dt?

$$\boxed{H = kA\frac{T_H - T_C}{L}}$$

$$\boxed{Q = Mc\Delta T}$$