

# PH202 Recitation 5

Thermo Part 2

# Warm-Up 1: 1 minute

- Say the following equation in words

$$Q = mc\Delta T$$

# Warm-Up 1 Solution

## Heat

The diagram shows the equation  $Q = mc\Delta T$  with four labels in boxes above it. Arrows point from each label to its corresponding variable in the equation: 'Heat' points to  $Q$ , 'mass' points to  $m$ , 'Specific Heat' points to  $c$ , and 'Change in Temperature' points to  $\Delta T$ .

$$Q = mc\Delta T$$

*In words:* The **heat** transferred to or from a system is equal to the product of the **mass**, **specific heat**, and **change in temperature**.

## Warm-Up 2: 1 minute

- Say the following equation in words

$$Q_f = \pm mL_f$$

# Warm-Up 2 Solution

## Heat of Transformation Fusion

The diagram shows the equation  $Q_f = \pm mL_f$ . Above the equation, three boxes contain labels: 'Heat of fusion' with an arrow pointing to  $Q_f$ , 'Mass' with an arrow pointing to  $m$ , and 'Latent heat of fusion' with an arrow pointing to  $L_f$ . The  $Q_f$  is written in red, while  $m$  and  $L_f$  are in black. The  $\pm$  symbol is underlined.

Heat of transformation is a material property that quantifies the energy required to undergo a phase transition from solid ↔ liquid.

*In words:* The **heat** of transformation fusion is equal to plus or minus the **mass** multiplied by the **latent heat** of fusion, which is a material property.

## Warm-Up 3: 1 minute

- Say the following equation in words

$$Q_v = \pm mL_v$$

# Warm-Up 3 Solution

## Heat of Transformation Vaporization

The diagram shows the equation  $Q_v = \pm mL_v$  with arrows pointing from labels to the variables. A box labeled "Heat of vaporization" has an arrow pointing to  $Q_v$ . A box labeled "Mass" has an arrow pointing to  $m$ . A box labeled "Latent heat of vaporization" has an arrow pointing to  $L_v$ .

$$Q_v = \pm mL_v$$

Heat of transformation is a material property that quantifies the energy required to undergo a phase transition from solid ↔ liquid.

*In words:* The **heat** of transformation vaporization is equal to plus or minus the **mass** multiplied by the **latent heat** of fusion, which is a material property.

# Warm-Up 4: 1 minute

## PROCESSES SUMMARY

MONATOMIC Z	ISOCORIC	ISOBARIC	ISOTHERMAL	ADIABATIC
$\Delta E_{TH}$	$\frac{3}{2}NK_B\Delta T$	$\frac{3}{2}NK_B\Delta T$	0	$\frac{3}{2}NK_B\Delta T$
Q	$\frac{3}{2}NK_B\Delta T$	$\frac{3}{2}NK_B\Delta T + P\Delta V$	$NK_B T \ln\left(\frac{V_f}{V_i}\right)$	0
W	0	$-P\Delta V$	$-NK_B T \ln\left(\frac{V_f}{V_i}\right)$	$\frac{3}{2}NK_B\Delta T$

# Discussion Question 1: 3 minutes

- Water is placed in a freezer and as it comes into thermal equilibrium it freezes. Which one of the following statements is true concerning this process?
  - a) The water gains entropy in accord with the second law of thermodynamics
  - b) The water loses entropy so the process violates the second law of thermodynamics
  - c) The water gains entropy, but the air inside the freezer loses entropy in accord with the second law of thermodynamics
  - d) Both the water and the air inside the freezer lose entropy, but the universe gains entropy in accord with the second law of thermodynamics
  - e) The water loses entropy, but the air inside the freezer gains entropy in accord with the second law of thermodynamics

## Question 1: 7 minutes

- I have a 0.500kg Aluminum pan with 0.250L of water in it. If I heat the system from 20°C to 120 °C , how much heat was required to do this? The specific heat of water is 4186 J/kg°C and the specific heat of Aluminum is 900 J/kg°C.

## Question 2: 7 minutes

- Sketch the following thermodynamic processes on a PV diagram and discuss how  $E_{th}$ ,  $Q$ , and  $W$  for each of the processes.
  - a) Isochoric
  - b) Isobaric
  - c) Isothermal
  - d) Adiabatic

# Challenge Homework Orientation

- A 0.15-kg aluminum can contains 0.2 kg of water. Initially, the water and the can have a common temperature of 18 °C. An unknown material ( $m=0.04$  kg) is heated to a temperature of 97 °C and then added to the water. The temperature of the water, the can, and the unknown material is 22 °C after thermal equilibrium is reestablished. Ignoring the small amount of heat gained by the thermometer, find the specific heat capacity of the unknown material.