Name:______________________________

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Physics 202

Quiz 2

8/5/2024

Collaboration is not allowed. Allowed on your desk are: two 8.5 x 11 inch doubled sided sheets of notes, any "survival sheets", a non-communicating graphing scientific calculator, a page of scratch paper, writing utensils, and the exam. You will have 40 minutes to complete this exam.

For questions 1 through 3, **fill in the square** next to all correct answers. A given problem may have more than one correct answer. Each correctly bubbled answer will receive two points. There are **6** correct answers in this section and only the first **6** filled in answers will be graded. There is no partial credit.

1. In the afternoon of a very cold, cloudless day, you park your car at the grocery store, turn off the engine, close the windows and doors and go inside the store to shop. When you come out of the store an hour later, the inside of your car is warm, even though it is cold outside. Which of the following statements are true?

   ☐ (a) The air **conducted** more heat into your car than your car **conducted** heat into the air.

   ☐ (b) Air is a very good insulator, so **conduction** strongly contributed to warming your car.

   ☑ (c) Your car has **radiated** heat into the air around it continuously during the last hour.

   ☑ (d) The air around the car has **radiated** heat into the car continuously during the last hour.

   ☑ (d) **Radiation** was a strong contributor to warming your car.

   ☐ (e) Air has **convected** through your closed car windows to warm the inside of your car.

   ☐ (f) Your car temperature will continue to increase because the rate of heat emission by your car increases with your car's temperature.

2. Three fair coins each have two sides, one side is labeled with a 1 and the other side is labeled with a 2. All three coins are flipped, then the numbers showing are totaled. Which of the following statements are true?

   ☐ (a) There are three possible **macrostates**.

   ☑ (b) Each **microstate** is equally probable.

   ☐ (c) Each **macrostate** is equally probable.

   ☐ (d) The most probable **macrostate** is a total roll of 3.

   ☐ (e) The most probable **macrostate** is a total roll of 7.

   ☑ (f) **Macrostate** totals of 4 and 5 are equally probable.

3	4	5	6
111	112	221	222
	121	212	
	211	122	

3. In an ideal gas of **2 moles**, the temperature is raised by a factor of **3** at the same time that the pressure decreases from **100 Pa** to **60 Pa**. By what factor must the volume change during this process?

   ☐ (a) Decreased by a factor of **3/40**

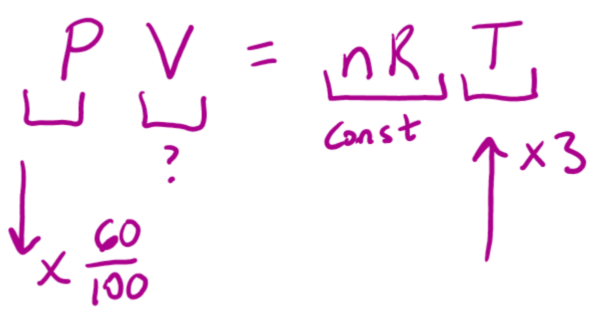
   ☐ (b) Decreased by a factor of **1/10**

   ☐ (c) Increased by a factor of **1.8**

   ☑ (d) Increased by factor of **5**

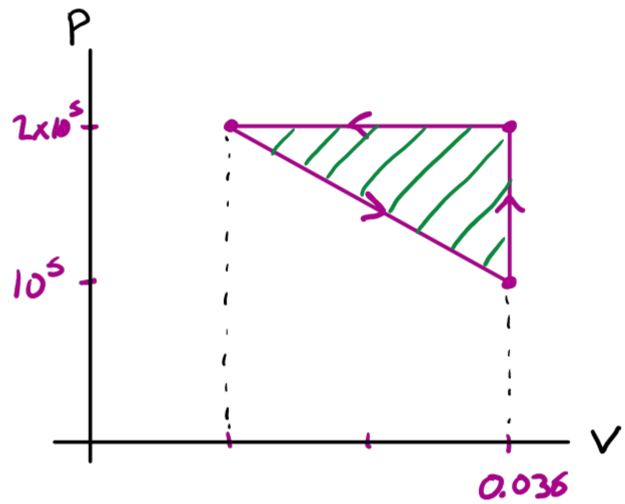
   ☐ (e) Increased by a factor of **6**

   ☐ (f) Increased by **120 m³**



4. (9 points) Initially, **1.3 moles** of ideal gas has a pressure of **10^5 Pa** and a volume of **0.036 m^3**. It then goes through the following processes. First, the pressure doubles during an isochoric process. Next, the volume is decreases to 1/3rd of the initial volume. Finally, it is returned to its initial state using a process that creates a straight line on a P vs V graph.

(a) Carefully and neatly draw the three processes on the included graph. Please make sure to label the graph axes with values.



(b) What is the magnitude of the total work done during the cycle?

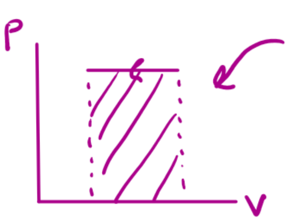
ΣW = area inside cycle

$= \frac{1}{2}$ (side)(side)

$= \frac{1}{2}\left(0.036 \times \frac{2}{3}\right)\left(10^5\right)$

= 1,200 J

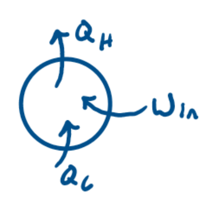
(c) Let's use related quantities sensemaking to analyze this system. Compare the quantity of work done while the gas is compressing with the quantity of work done while the gas is expanding. Which is bigger, if either? Finally, what does this comparison tell us about whether this cycle is a heat pump, heat engine, or neither (and which is it)? Explain using any combination of words, diagrams, math, etc.



Work during compression ⇒ energy is entering gas

Work during expansion ⇒ energy is leaving gas

More work is done during compression, which means more work enters the gas than leaves. This is a heat pump, which requires work input.



5. (9 points) A **0.1 kg block of solid water ice** is placed onto a **2.3 kg block of hot copper**. The ice is initially at **0 °C**. The system is isolated from the environment. The copper block has a change of temperature of **–70 °C** before the system reaches thermal equilibrium.

Material	**k** (W / m K)	**c** (J / kg K)	L_F (J / kg)	L_V (J / kg)
Water (solid)	2.1	2108	3.36×10^5	
Water (liquid)	0.6	4184	3.36×10^5	2.26×10^6
Copper	401	385	2.05×10^5	5.07×10^6

(a) How much energy would it take to fully melt the ice? (but not warm it up!)

$$\Delta E = \pm m L_f$$

$$\Delta E = (0.1\ \text{kg})(3.36 \times 10^5\ \tfrac{\text{J}}{\text{kg}})$$

$$\Delta E = 33{,}600\ \text{J}$$

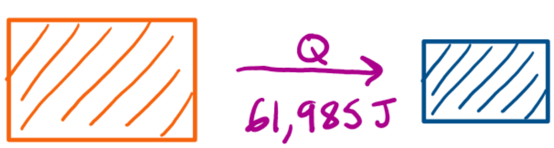
(b) how much energy did the copper lose?

$$\Delta E = m c \Delta T$$

$$= (2.3\ \text{kg})(385\ \tfrac{\text{J}}{\text{kg K}})(-70\ \text{K})$$

$$= 61{,}985\ \text{J}$$

(c) What was the **initial** temperature of the copper?



33,600 J went to melt ice

61,985 − 33600 = 28,385 went to warm liquid water

$$\Rightarrow \Delta E_w = m c \Delta T_w$$

$$\Delta T_w = \frac{\Delta E}{mc} = \frac{28{,}385\ \text{J}}{(0.1\ \text{kg})(4184\ \tfrac{\text{J}}{\text{kg K}})} = 67.8^\circ\text{C}$$

$$\Rightarrow T_{f,\text{water}} = 67.8^\circ\text{C} = T_{f,\text{copper}}$$

b/c equilibrium

from problem statement

$$\Delta T_{copper} = -70^\circ\text{C}$$

$$\Rightarrow T_{i,\text{copper}} = 137.8^\circ\text{C}$$