Physics 152 Second Exam Review Suggestions

1. What are temperature, specific heat, latent heat, and thermal energy transfer? How are they related? When different amounts of substances of different types, masses, and temperature are in thermal contact, how can their final equilibrium temperature be calculated? Are final temperature calculations the same when one of the substances undergoes a phase change? Does matter have to be exchanged in order for temperature to change? Is heat a substance?

2. What is the first law of thermodynamics? How is the thermal energy transferred to (or from) a system related to the work done by a system (or on a system by its surroundings) and its internal energy? Do scientists believe that energy is conserved in thermal systems?

3. What is the basic definition of pressure or mechanical work? How can that definition be used to develop a method for calculating the work done by a gas when its volume changes at known pressures? What is the difference between adiabatic, isothermal, isovolumetric, and isobaric changes in the volume, temperature, and pressure of a gas? How can you calculate the work done by or on a gas in each of these 4 types of expansions or compressions or pressure changes?

4. What is the ideal gas law? How was it found using the Kinetic Theory of Gases? How do scientists assume that the molecules in an ideal gas behave when they collide with each other or with the walls of a perfectly insulated container? If the ideal gas law is to hold for a gas consisting of these "ideal molecules" how is the temperature of the gas related to the energies of the molecules. How is the internal energy of the gas related to its temperature and the number of molecules in it?

5. Consider heat engines that have an ideal gas as the working medium. Can you explain why the working medium in all heat engines must be alternately in contact with hot and cold substances? Can you use the first law of thermodynamics and your understanding of various ways that the gas can undergo changes in P, V, and T, to analyze the work done, thermal energy transferred, and the change in internal energy in an engine cycle, and find the efficiency of an engine (You will want to be able to do this type of problem for any combination of processes that make up a cycle (including processes that are ***not*** isothermal, isobaric, isovolumetric, or adiabatic, *e.g.*, calculating work by finding the area of triangles and rectangles)). How does the engine's efficiency compare to the efficiency of a Carnot cycle operating between the same two temperatures?

Sample Problems

I. Concepts:

1. (20 points)
Identify which of the following statements are true and which are false for *all four* of the statements below (Circle the **T** or **F** in each case). In addition, for **two of the four** statements describe at *least one observation, experiment or calculation you actually performed* that supports your contention that the statement is true or false. **Be as specific as possible about the actual observation, experiment or calculation you performed. Cite the activity number and briefly describe the activity and its outcome.**

T or F ? (a) Whenever thermal energy is transferred from a hotter body to a cooler body, the temperature of the cooler body always rises. (True or False?)

T or F ? (b) Once thermal energy enters a system 100% of it always serves to increase the internal energy of a system. (True or False?)

T or F ? (c) The temperature of an ideal gas is proportional to the average kinetic energy of its molecules. (True or False?)

T or F ? (d) Thermal energy is a form of energy that can only be transferred from one system to another by means of an exchange of matter. (True or False?)

Description of Activity for item (Circle One) (a) (b) (c) (d)
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II. Kinetic Theory of Gases (20 points):

The kinetic-molecular theory is very useful in describing the many properties that we observe in gases. However, it really works best for an "ideal" gas, and fails to account for the behavior of real gases at high pressure and/or low temperatures.

(a) **(5 points)** Identify/list the assumptions you used in the kinetic theory to develop the ideal gas law.

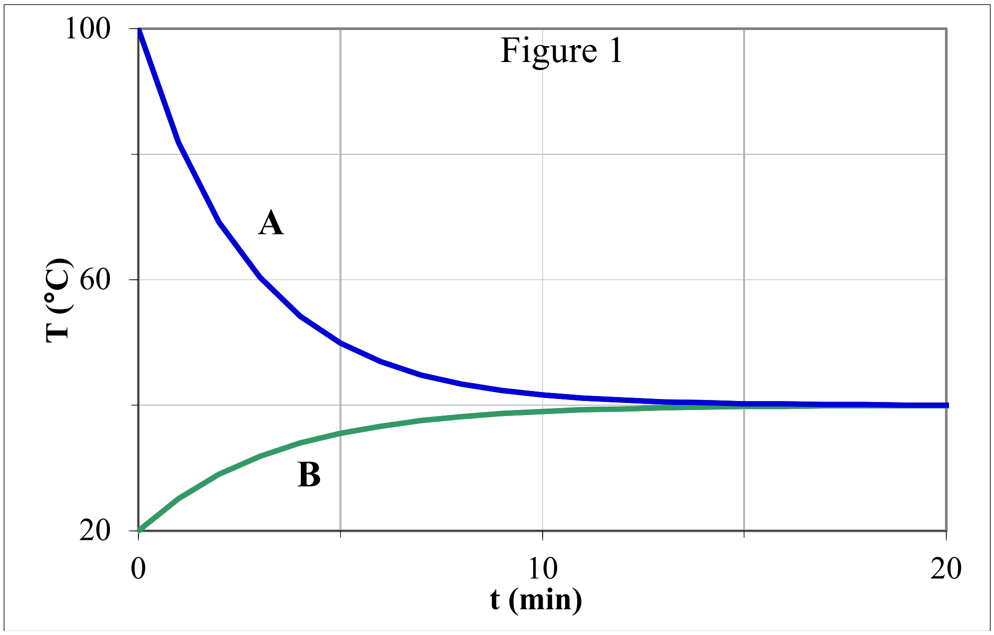
(b) **(5 points)** Two different ideal gases are at the same temperature. What can you say about how the average speeds of the gas molecules compare with each other?

(c) **(5 points)** If an ideal gas in a container is warmed at constant volume, explain in terms of molecular motion whether the pressure on the walls of the container decreases, increases, or stays the same, and why.

(d) **(5 points)** If the volume of an ideal gas in a container is reduced at constant temperature, explain in terms of molecular motion whether the pressure on the walls of the container decreases, increases, or stays the same, and why.

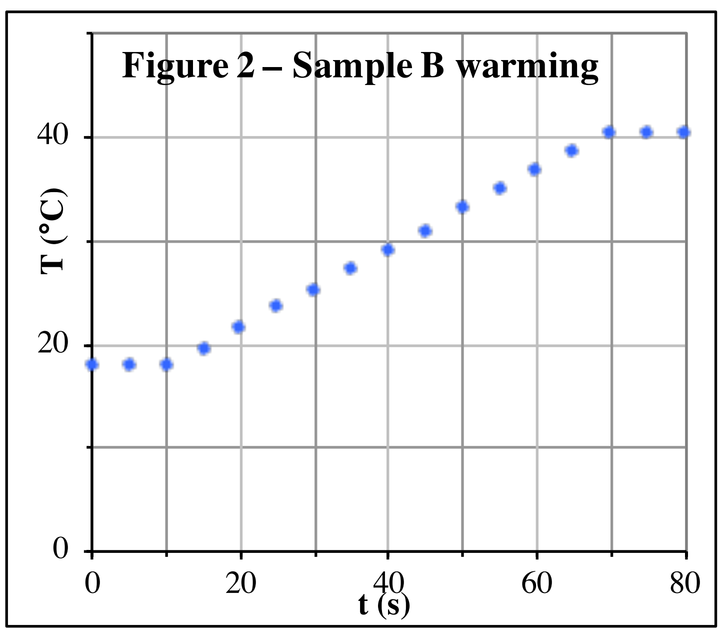
III. Data Analysis (20 points):

Samples of material A and material B are at different initial temperatures when they are placed in a thermally insulated container and allowed to come to thermal equilibrium. Figure 1 below gives their temperatures T versus time t. Sample A has a mass of 5.0 kg, and sample B has a mass of 1.5 kg.



In a separate experiment, 200 g of the material B is placed in a thermally insulated container, and thermal energy is added to it at a constant rate using an immersion heater (certified at 300 W). Figure 2 below gives the results of that particular experiment.

t **(s)**	***T*** **(°C)**
0	**18.0**
5	**18.0**
10	**18.0**
15	**19.6**
20	**21.5**
25	**23.6**
30	**25.3**
35	**27.3**
40	**29.1**
45	**30.8**
50	**33.1**
55	**34.9**
60	**36.9**
65	**38.6**
70	**40.5**
75	**40.5**
80	**40.5**

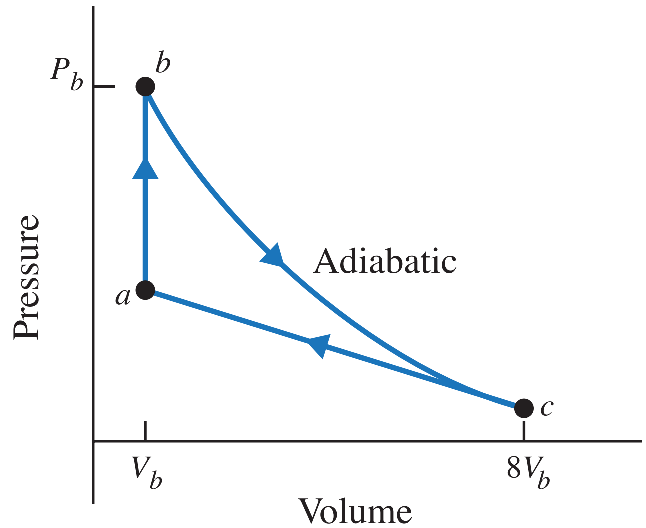


Based on this information and data, find the specific heat of material A.

IV. Problems (30 points):

1. (20 points) Heat Engine

One mole of a monatomic ideal gas is taken through the cycle $a \rightarrow b \rightarrow c \rightarrow a$ shown below. Process $b \rightarrow c$ is an adiabatic expansion, with P_b = 10.0 atm and $V_b = 1.00 \times 10^{-3}$ m^3. Also, the temperature at state a is T_a = 30.5 K. (**Careful**: the horizontal axis doesn't necessarily cross the vertical axis at P = 0 atm, *i.e.*, you can't estimate P_a or P_c by just looking at the scale.)



(a) **(8 points)** Find the change in internal energy, ΔE^{int}, in Joules for each step in the cycle. Show your calculations and fill in your results in the table shown on the next page.

(b) **(7 points)** Calculate the work done, W^{sys}, in Joules for each step in the cycle. Show your calculations and fill in your results in the table shown below. In each case, indicate (in the table) whether work is done by the system or is done on the system.

(c) **(5 points)** Find the amount of thermal energy transferred, Q, in Joules for each step in the cycle. Show your calculations and fill in your results in the table shown below. In each case, indicate (in the table) whether thermal energy is absorbed from the surroundings or thermal energy is given off to the surroundings.

	a → b	**b → c**	**c → a**
ΔE^{int}			
W^{sys}			
Q			

2. (10 points) 1st and 2nd Law of Thermodynamics

An inventor claims to have invented four cyclic engines, each of which works between a constant temperature hot reservoir of temperature 400 K and a constant temperature cold reservoir of temperature 300 K. Data on each, per cycle of operation, are:

Engine A: $|Q_{hot}| = 200$ J, $|Q_{cold}| = 175$ J, and $W^{sys} = 40$ J

Engine B: $|Q_{hot}| = 500$ J, $|Q_{cold}| = 200$ J, and $W^{sys} = 400$ J

Engine C: $|Q_{hot}| = 600$ J, $|Q_{cold}| = 200$ J, and $W^{sys} = 400$ J

Engine D: $|Q_{hot}| = 100$ J, $|Q_{cold}| = 90$ J, and $W^{sys} = 10$ J

(a) **(5 points)** Do any of the engines violate the 1st Law of thermodynamics, and if so, which one(s)? Do any of the engines violate the 2nd Law of thermodynamics, and if so, which one(s)?

(b) **(5 points)** Would you invest in any of his engines? *Discuss the physical reasons for your answer.*