Name: _____

PHYS 1220-02 Exam 1

You may use an 8.5"×11" note sheet written on both sides and a calculator. Please write your answers in the boxes provided. Show your work outside the boxes. If you need to change the answer you wrote in a box, erase it and write your intended answer. This is easiest if you write in pencil. You have 110 minutes.

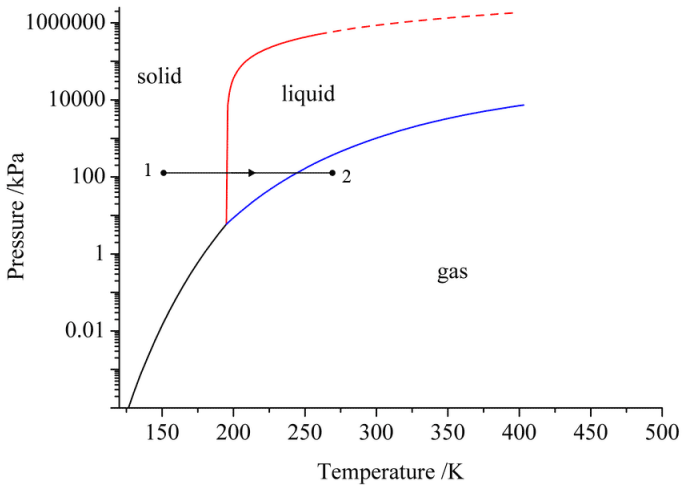
All gases are ideal unless otherwise indicated. Some physical constants you may need are

Universal gas constant R	8.31446 J/(mol·K)
Boltzmann constant k_B	1.380649×10^{-23} J/K
Avogadro's number N_A	6.02214×10^{23}/mol

1. A can of tennis balls with an interior volume of 0.200 liters (not including the tennis balls) is packed with nitrogen (N_2) gas at 1.50×10^5 Pa pressure at a temperature of 24.0°C. The can is cooled to -5.0°C, maintaining a constant volume. How much heat is released by the nitrogen gas? We're not concerned with the tennis balls, or with any gas inside the tennis balls, just the packing gas.

2. In a balloon, 1.70 liters of argon (Ar) gas at 18.0°C absorbs 16.0 joules of heat from its surroundings. The internal pressure of the balloon remains constant at 9.00×10^4 Pa while the balloon expands and its temperature increases. What is the final temperature of the gas?

3. A phase diagram for ammonia (NH_3) is shown at right. Marked on the diagram is a path from state 1 to state 2.



   A. Sketch a qualitative volume (vertical axis) vs. temperature (horizontal axis) plot to show how the volume of a sample of ammonia responds to changing temperature along the path from state 1 to state 2.

   B. Sketch a qualitative heating curve for ammonia along this path. This is a plot of temperature (vertical axis) vs. heat input (horizontal axis).

4. In a steam engine, 100 kilograms of water at 180°C and a pressure of 1.00×10^6 Pa boils to steam at constant pressure. In this process, the water absorbs 201.4×10^6 J of heat and its volume increases from 0.113 m^3 to 19.40 m^3.

   A. How much work is done by the water in this process?

   B. What is the change in internal energy of the water in this process?

   C. What is the entropy change of the water in this process?

   D. If only 50 kg of water had been boiled in this process, how would its entropy change compare? Select the one best answer by filling its circle.

   ○ a. It would be the same as for 100 kg water.

   ○ b. It would be half as much as for 100 kg water.

   ○ c. It would be ¼ as much as for 100 kg water.

   ○ d. It would be $1/\sqrt{2}$ as much as for 100 kg water.

   ○ e. It would be $\ln(2)$ as much as for 100 kg water.

   ○ f. It would be ln (½) as much as for 100 kg water.

   ○ g. It would be $e^{1/2}$ as much as for 100 kg water.

   ○ g. It would be e^{-2} as much as for 100 kg water.

5. Air (a diatomic gas) in a diesel cylinder, 180. mL (1.80×10^{-4} m^3) and initially at a temperature of 300 K and pressure of 8.9×10^4 Pa, is adiabatically compressed to a volume of 10.0 mL.

   A. What it the temperature of the air after compression?

   B. What is the pressure of the air after compression?

   C. How much work was done to compress the air?

6. In a particular process, the entropy of a system increases by 11.8 J/K. What is the change in multiplicity Ω_f / Ω_i of the system? (Ω_f is the multiplicity of the final state; Ω_i is the multiplicity of the initial state.) You may not be able to calculate the number, but at least put the proper quantities into the formula.

7. The thermodynamic definition of temperature that we developed in this class is

$$\frac{1}{T} = \frac{dS}{dU}$$

A. Does the *T* in this formula represent absolute temperature, or could it be expressed in Celsius or Fahrenheit? Select the one best answer by filling its circle.

○ a. This formula works only for absolute temperature.

○ b. Celsius temperature could be used in the formula, but not Fahrenheit.

○ c. Fahrenheit could be used if *U* and *S* are expressed in consistent units.

B. Knowing that $\Delta S > 0$ for every spontaneous process, show or explain how this definition requires that heat spontaneously flows from high temperature to low temperature.

8. In the dice-rolling diffusion simulation exercise I forced you to conduct in class, the beginning state had 100 dice in Zone 3, with zones 1, 2, 4, and 5 unoccupied. Explain conceptually why this starting state has lower entropy than a state in which there are approximately the same number of dice in each zone.