General Physics I **Exam 5 - Ch. 13,14 - Thermal Physics** **Dec. 3, 2008**

Name: Rec. Instr.: Rec. Time:

Make your work clear to the grader. Show the formulas you use, all the essential steps, and results with correct units and number of significant figures. Partial credit is available if your work is clear. Point values are given in parenthesis. Use 1 L=10^{-3} m^3, 1 atm=101.3 kPa, 1 cal=4.186 J, 1 u=1.6605×10^{-27} kg,
$R = 8.3145$ J/mol·K, $N_A = 6.022 \times 10^{23}$/mol, $k = 1.38 \times 10^{-23}$J/K, $\sigma = 5.67 \times 10^{-8}$ W/m^2· K^4.

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1. (2) In the Periodic Table of the Elements, the "mass number" for helium is 4.0026. This means that

   a. on average, 4.0026 He atoms form a molecule. b. there are 4.0026 grams of He in a liter.
   c. there are 4.0026 kilograms of He in a cubic meter. d. there are 4.0026 grams of He in a mole.
   e. there are 4.0026 kilograms of He in a mole.

2. (2) Of these elements, which has the largest number of **atoms** in a **mole** of the substance?

   a. helium (He) b. oxygen (O) c. aluminum (Al) d. all have the same number.

3. (2) Of these elements, which has the largest number of **atoms** in a **gram** of the substance?

   a. helium (He) b. oxygen (O) c. aluminum (Al) d. all have the same number.

4. (2) Of these elements, which has the largest **mass** in a **mole** of the substance?

   a. helium (He) b. oxygen (O) c. aluminum (Al) d. all have the same mass.

The gases O_2, CO_2, He, and CH_4, all behave as ideal gases at 1 atm and 295 K.

5. (2) Which, as a pure gas, has the **lowest density** at 1 atm and 295 K?

   a. oxygen (O_2) b. carbon-dioxide (CO_2) c. helium (He) d. methane (CH_4) e. all the same.

6. (2) Which, as a pure gas, has the most **molecules per cubic meter** at 1 atm and 295 K?

   a. oxygen (O_2) b. carbon-dioxide (CO_2) c. helium (He) d. methane (CH_4) e. all the same.

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7. (2) When an ideal gas is heated from temperature 300 K to 600 K, the average translational kinetic energy of the molecules is changed by a factor of

   a. 0.5 b. 1.0 c. 1.5 d. 2.0 e. other _____

8. (2) The temperature inside a tank of gas is -40° C. Which of the following is closest to but still above this temperature?

   a. 40 K b. 77 K c. 210 K d. 240 K e. 295 K.

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9. (10) Consider normal air at 295 K and 1.00 atm, which contains a mixture of many molecules, including nitrogen, oxygen, water vapor and carbon-dioxide.

   a) (2) Which of these listed molecules has the highest rms speed?

   a. N_2 b. O_2 c. CO_2 d. H_2O e. all have the same rms speeds.

   b) (2) Which of these listed molecules has the highest average translational kinetic energy $\overline{\text{KE}}_{\text{trans}}$?

   a. N_2 b. O_2 c. CO_2 d. H_2O e. all have the same $\overline{\text{KE}}_{\text{trans}}$.

   c) (6) Find the rms speed at 295 K and 1.00 atm for the fastest of the molecules listed.

10. (12) Suppose a regular 2.0-liter plastic coke bottle is filled with helium gas until reaching a pressure of 12.0 atm at temperature 30.0°C.

a) (6) How many kilograms of helium are inside the bottle?

b) (6) If the gas is allowed to escape and remains at 30.0°C, what new volume will it occupy?

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11. (6) The coefficient of thermal expansion for aluminum is 25 $\times 10^{-6}$/°C. What temperature change ΔT is required to cause a 4.00 m long aluminim rod to expand by 1.00 cm?

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12. (2) The internal energy of an **ideal gas** is due to molecular

a. kinetic energy only b. potential energy only c. kinetic and potential energy combined.

13. (2) **T** **F** The internal energy of an ideal gas is proportional to its absolute temperature.

14. (2) **T** **F** 1.00-kg of 0°C ice has less volume than 1.00-kg of 0°C water.

15. (2) **T** **F** A balloon filled with water at 4.0 °C will sink when placed in a container of water at 0.0°C.

16. (2) **T** **F** The heat applied to melt 1 kg of ice is greater than the heat removed to freeze 1 kg of water.

17. (2) **T** **F** The internal energy of 1.00 kg of water vapor at 100°C is the same as the internal energy of 1.00 kg of liquid water at 100°C.

18. (4) A hot 2.0-kg lead mass ($c = 130$ J/kg·C°) loses heat when thrown into 1.00-kg of cold water ($c = 4186$ J/kg·C°) in an insulated container.

a) (2) Which substance experiences the larger magnitude heat transfer Q?

a. the lead. b. the water. c. their Q's have the same magnitudes.

b) (2) Which substance experiences the larger magnitude temperature change ΔT?

a. the lead. b. the water. c. their ΔT's have the same magnitudes.

19. (12) An insulated container initially holds 1.00 kg of ice at 0.00°C. There is enough space above the ice to allow steam at 100.0° to enter the container slowly through a small pipe. Steam is slowly added until all the ice melts; now the container holds water at 0.0°C [H_2O Latent Heats: $L_F = 333$ kJ/kg, $L_V = 2260$ kJ/kg].

a) (6) How much heat did the steam transfer to the ice originally in the container?

b) (6) What mass of steam was added to the container?

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20. (10) A 45000-kg truck travelling at 140 km/h suddenly brakes to a stop using conventional friction brakes.

a) (2) By braking, the truck's kinetic energy becomes primarily

a. potential energy in the brake fluid.
b. kinetic energy in the brake fluid.
c. kinetic energy in the brake pads.
d. internal energy in the brake pads.

b) (8) How much 100°C water could be vaporized by the heat equivalent to the truck's KE?

21. (8) A 72-kg marathon runner has average metabolic rate of 950 kcal/h (rate of body producing waste heat). Assuming the body has specific heat of 3470 J/kg·C°, what temperature rise would the marathoner's body experience in a race of 2.5 hours if this heat could not be dissipated?

22. (8) One day, sunlight of intensity 880 W/m^2 is shining on a 50.0m $\times$ 100.0 m soccer field that has emissivity $e = 0.50$. The sun is 35° above the horizon.

a) (2) **T** **F** The rate at which solar energy is incident on the entire field would be more than doubled if the sun were directly overhead.

b) (6) Calculate the rate at which the entire field is **absorbing** sunlight.

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23. (12) Suppose your body (together with your clothes) has an average surface temperature of 25°C, and a total surface area of 1.5 m^2. Consider the heat your body is losing by radiation alone.

a) (6) If you are surrounded by an extremely cold environment (0 Kelvin), and your clothes are very dark (high emissivity) at what net rate is your body losing energy, due to radiation?

b) (6) On the other hand, if you are surrounded by a heated house at 20°C, and the emissivity of your clothes is low (only 0.20), at what net rate is your body losing energy via radiation?