Name:

Make your work clear to the grader. Show formulas used. Give correct units and significant figures. Partial credit is available if your work is clear. Point values are given in parenthesis.

Prefixes: f=10^{-15}, p=10^{-12}, n=10^{-9}, $\mu = 10^{-6}$, m=10^{-3}, c=10^{-2}, k=10^{3}, M=10^{6}, G=10^{9}, T=10^{12}, P=10^{15}.

Use 1.0 atm=101.3 kPa, $R = 8.3145$ J/mol·K, $N_A = 6.022 \times 10^{23}$/mol, $k = 1.38 \times 10^{-23}$J/K, 1 cal = 4.186 J.

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1. (2) If you have a mole of helium atoms, what mass of helium do you have?

   a. 1.0 g. b. 2.0 g. c. 4.0 g. d. 8.0 g. e. 12 g. f. 16 g.

2. (2) If you have a mole of water molecules, what mass of water do you have?

   a. 4.0 g. b. 8.0 g. c. 10. g. d. 16. g. e. 18. g. f. 20. g.

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

   a. hydrogen (H) b. carbon (C) c. copper (Cu) d. all have the same number.

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

   a. hydrogen (H) b. carbon (C) c. copper (Cu) d. all have the same number.

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5. (12) A helium balloon at room temperature of 25.0 °C and 1.00 atm pressure has a volume of 25.0 L.

   a) (6) What mass of helium does the balloon contain?

   b) (6) If the balloon is taken under water to a depth where the pressure is 20.0 atm and the temperature is -5.00 °C (salt water freezes at lower temperature than fresh), what is the new volume of the balloon?

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6. (6) Show all the steps of how to convert 50.0 °F into its equivalent on the Kelvin scale.

7. (2) At which temperature and phase does pure H_2O have the highest density? Assume 1.00 atm pressure.

a. ice at 0.0 °C. b. water at 0.0 °C. c. water at 4.0 °C. d. water at 100 °C. e. steam at 100.0 °C.

8. (2) If the temperature of an ideal gas changes from 100 K to 300 K, while the pressure changes from 1.00 atm to 3.00 atm, the average translational kinetic energy per molecule changes by a factor of

a. 9 b. 3 c. $\sqrt{3}$ d. $1/\sqrt{3}$ e. 1/3 f. 1/9

9. (2) In a mixture of the following ideal gases at 300 K and 1.00 atm, which has the highest rms molecular speed?

a. CH_4 (methane) b. O_2 (oxygen) c. N_2 (nitrogen) d. H_2O (water vapor) e. all tie.

10. (2) In a mixture of the following ideal gases at 300 K and 1.00 atm, which has the highest average translational kinetic energy?

a. CH_4 (methane) b. O_2 (oxygen) c. N_2 (nitrogen) d. H_2O (water vapor) e. all tie.

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11. (16) For propane molecules [C_3H_8] that leak from the heating system into a house at 22 °C and 1.00 atm pressure,

a) (6) Calculate their rms speed.

b) (6) Calculate the total kinetic energy of translation for a mole of propane molecules (a.k.a. the molar internal energy due to translational KE) at 22 °C and 1.00 atm pressure.

c) (4) Calculate the ratio of rms speeds for propane molecules compared to oxygen molecules.

Name:

1. (2) The internal energy of an ideal gas is directly proportional to its

 a. absolute temperature. b. pressure. c. volume. d. density.

2. (2) Internal energy of an ideal gas is due to molecular

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

3. (2) **T F** Heat is an energy transfer always from a colder object to a hotter object.

4. (2) **T F** Any phase change of a material always involves an increase in its internal energy.

5. (2) **T F** A 1.0 kg sample of copper originally at 100 °C gives at certain quantity of heat to a 2.0 kg sample of copper originally at 50 °C. Which experiences the greater magnitude temperature change?

 a. The 1.0 kg sample. b. The 2.0 kg sample. c. It's a tie.

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6. (10) A thermally insulated bucket holds 5.00 L water initially at 20.0 °C. A 10.0-kg block of iron initially at 145°C is thrown into the bucket, and the water is thoroughly mixed until everything reaches the same temperature. The specific heat of iron is 450 J/kg·K. The mass and heat capacity of the bucket itself are negligible.

a) (2) Which undergoes the larger magnitude of heat transfer?

 a. The 5.00 L of water. b. The 10.0 kg of iron. c. It's a tie.

b) (8) Set up an equation for the heat exchanges, using it to find the final temperature of the water+iron.

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7. (8) I want my freezer to make 10.0 kg ice at -8.00°C, starting from 10.0 kg of liquid water at 25.0°C. How much total heat must be transfered out of the water to accomplish this?

8. (8) Suppose you have a small amount of water, say, 1.00 gram, soaked into your clothing. If the air is very dry, and a swift breeze suddenly evaporates 1.0% of that water, by how many degrees celsius could the remaining water have cooled by evaporative cooling? [Hint: $L_V = 2260$ J/g, and ignore heat exchanged with the clothing or body.]

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9. (6) A metal sphere with emissivity of 0.55 and radius of 3.0 cm is being heated to 420 K by an electric current (just like an incandescent light bulb filament). If the sphere's surroundings are at a temperature 310 K, at what net rate (watts) is the sphere exchanging heat with the surroundings, due to radiation?

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10. (10) Solar energy is proposed as a plentiful source of renewable energy. Suppose a system is installed on a house with a flat level roof of area 220 m^2 and emissivity 0.80 . Assume that the sun makes an average angle of 75 $^\circ$ above the horizon during 10.0 hours per day, and the solar constant is 1050 W/m^2 at Earth's surface.

a) (6) How much solar energy (joules) can be absorbed on the roof in any "10-hour day?"

b) (4) If half of the energy being absorbed could be converted to usable electric power, what average power (watts) would you get during the 10-hour day when the sun is shining?

Name:

1. (2) If a gas is compressed adiabatically, which quantity or quantities are zero? Check all that apply.

   a. ΔU b. ΔT c. Q d. W e. ΔP.

2. (2) When a process is performed isobarically, which quantity or quantities are zero? Check all that apply.

   a. ΔU b. ΔT c. Q d. W e. ΔP.

3. (2) When a process on an ideal gas is isothermal, which quantity or quantities are zero? Check all that apply.

   a. ΔU b. ΔT c. Q d. W e. ΔP.

4. (2) In a typical refrigerator or air conditioning unit, which type of process is most responsible for the cooling?

   a. isobaric b. isothermal c. adiabatic d. isochoric

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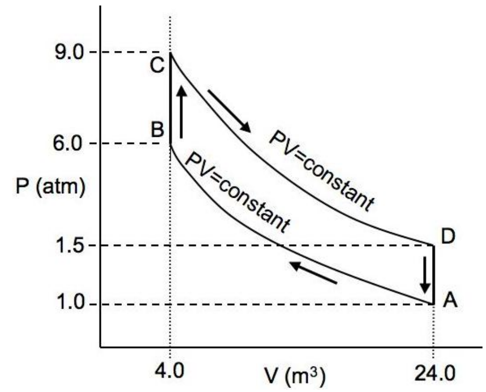
5. (12) A sequence of processes are performed on a quantity of ideal gas, as shown in this PV diagram, taking the gas between states A, B, C, and D. The temperature in state A is 3.00×10^2 K.



a) (2) Which process is an isothermal expansion?

   a. AB b. BC c. CD d. DA e. there isn't one.

b) (2) Which process is an isobaric compression?

   a. AB b. BC c. CD d. DA e. there isn't one.

c) (2) In which process does the internal energy decrease?

   a. AB b. BC c. CD d. DA e. there isn't one.

d) (2) In which process does the temperature increase, but the work = 0 ?

   a. AB b. BC c. CD d. DA e. there isn't one.

e) (4) The temperature for state A is 3.00×10^2 K. Find the temperature for state C.

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6. (12) In an adiabatic *expansion* of 0.500 mole of ideal monatomic gas, a work of 125 J is involved.

a) (2) **T F** The 125 J is the work done *on* the gas.

b) (4) Calculate the change in internal energy of the gas, ΔU.

c) (6) What change in temperature of the gas takes place? Is it a temperature **increase** or **decrease**? ← select.

7. (6) While pumping up a bicycle tire, Lance's tire pump pushes a volume of 0.080 L of air into the tire with each stroke of the hand pump. The pressure inside the tire is about 6.0 atm. Assume the pumping is an isobaric process. After doing 20 pumping strokes, how much **work** did Lance do on the air pumped into the tire?

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8. (16) A heat engine that powers an electric generator burns fuel at 1400 K and exhausts heat at 350 K. Its actual mechanical power output is 88.0 kW, but it produces exhaust heat at the rate of 112 kW.

a) (4) How large is the maximum theoretical operating efficiency?

b) (6) Calculate the actual operating efficiency of the engine.

c) (6) If the fuel burned is gasoline (energy content of 130. MJ/gallon), how much fuel will the engine use during 1.00 hour of operation?

Chapter 15 Equations

First Law of Thermodynamics (U = internal energy):

$\Delta U = Q - W$ or $\Delta KE + \Delta PE + \Delta U = Q - W$

work = W = area under $P(V)$ curve. $W = P\Delta V$ for isobaric processes.

heat = Q = heat absorbed by the system. $Q = 0$ for adiabatic processes.

Engines:

efficiency $e = \frac{W}{Q_H} = 1 - \frac{Q_L}{Q_H}$, $Q_H = Q_L + W$, $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$ for ideal Carnot cycle.

Cooling Machines, Heat Pumps:

refrigerators: COP $= \frac{Q_L}{W}$, heat pumps: COP $= \frac{Q_H}{W}$, $\frac{Q_L}{Q_H} = \frac{T_L}{T_H}$ for ideal Carnot.

Chapter 14 Equations

Internal Energy:

$U = \frac{3}{2}NkT = \frac{3}{2}nRT$, for ideal monatomic gases.

Mechanical Equivalent of Heat, Specific Heat, Latent Heat:

1 cal = 4.186 J, $Q = mc\Delta T$, $Q = mL_F$, $Q = mL_V$.

For water, $c = 1.00$ cal/g·C° = 4.186 kJ/kg ·C°, $c_{\text{ice}} = 0.50$ cal/g·C° = 2.1 kJ/kg ·C°.

$L_F = 79.7$ kcal/kg = 333 kJ/kg, $L_V = 539$ kcal/kg = 2260 kJ/kg.

Heat Transfer:

Conduction: $P = \frac{Q}{t} = kA\frac{\Delta T}{l}$.

Radiation: $P = \frac{\Delta Q}{\Delta t} = e\sigma AT^4$, $P = \frac{\Delta Q}{\Delta t} = e\sigma A(T_1^4 - T_2^4)$, $\sigma = 5.67 \times 10^{-8}$ W/m²· K⁴.

Solar Energy: $P = \frac{\Delta Q}{\Delta t} \approx (1000 \text{ W/m}^2)\ eA\cos\theta$

Chapter 13 Equations

Atomic Theory & Moles:

$n = \frac{N}{N_A}$, $n = \frac{m}{M_A}$, $N_A = 6.022 \times 10^{23}$/mol, $1\text{ u} = \frac{1\text{ gram}}{N_A} = 1.6605 \times 10^{-27}$ kg.

Temperature scales:

T(°C) = $\frac{5}{9}$[T(°F)-32], T(°F)=$\frac{9}{5}$ T(°C)+32, T(K)=T(°C)+273.15

Thermal Expansion:

$\Delta L = \alpha L_0 \Delta T$, $\Delta V = \beta V_0 \Delta T$.

Ideal Gas Law:

$PV = nRT$, or $PV = NkT$, $R = 8.314$ J/mol·K, $k = \frac{R}{N_A} = 1.38 \times 10^{-23}$ J/K.

Kinetic Theory:

$\bar{\text{KE}} = \frac{1}{2}mv_{\text{rms}}^2 = \frac{3}{2}kT$, $v_{\text{rms}} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M_A}}$.

Vectors

Written $\vec{V}$ or $\mathbf{V}$, described by magnitude=V, direction=θ or by components (V_x, V_y).

$V_x = V\cos\theta, \quad V_y = V\sin\theta,$

$V = \sqrt{V_x^2 + V_y^2}, \quad \tan\theta = \frac{V_y}{V_x}.$ θ is the angle from $\vec{V}$ to $+x$-axis.

Addition: $\mathbf{A} + \mathbf{B}$, head to tail. Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $-\mathbf{B}$ is $\mathbf{B}$ reversed.

Trig summary

$\sin\theta = \frac{(\text{opp})}{(\text{hyp})}, \quad \cos\theta = \frac{(\text{adj})}{(\text{hyp})}, \quad \tan\theta = \frac{(\text{opp})}{(\text{adj})}, \quad (\text{hyp})^2 = (\text{opp})^2 + (\text{adj})^2.$