Announcements

1. **Exam 4 starts Friday!**
   a. Available in Testing Center from Friday, Dec 7 (opening time), up to Monday, Dec 10 at 4:00 pm.
      i. Late fee if you start your exam after 4 pm
   b. Covers Ch. 9-12 (up through HW 20)
   c. Sample Exam 4 is posted on the website and Sample Exam 4 Solutions also.
   d. Exam 4 formulas posted on website: which ones you need to memorize, and which ones will be given
      i. Also in today's notes
   e. There's still a **3 hour time limit**
2. Late submissions for HWs 17 through 20 are due Friday evening
3. Online course evaluations, do before Dec 13
   http://studentratings.byu.edu
4. Final exam info
   a. Take in Testing Center any time during Finals week
   b. No time limit, but approx. same length as other exams
   c. Approx 40-45 problems (answer blanks)
      i. Approx. 10-12 on new stuff (Chap 13 & 14), the rest is cumulative
      ii. Not as many of the hardest problems

Exam 4 formulas (the new ones)

To be given on exam

New for exam 4

Constants

ρ_{water} = 1000 kg/m^3

$k_B = 1.381 \times 10^{-23}$ J/K

$N_A = 6.022 \times 10^{23}$

$R = k_B \cdot N_A$ = 8.314 J/mol·K = 0.08206 liter·atm/mol·K

$\sigma = 5.67 \times 10^{-8}$ W/m^2·K^4

Conversion factors:

1 atm = 1.013×10^5 Pa = 14.7 psi

$T_F = \frac{9}{5}T_C + 32$

$T_K = T_C + 273.15$

1 cal = 4.186 J

1 m^3 = 1000 L

stress = F/A; strain = $\Delta L/L$

$P = P_0 + \rho gh$

$A_1v_1 = A_2v_2$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$\Delta L = \alpha L_0 \Delta T$

$\Delta V = 3\alpha V_0 \Delta T$

$KE_{ave} = \frac{1}{2}mv_{ave}^2 = \frac{3}{2}k_B T$

$\frac{\Delta Q}{\Delta T} = kA\frac{T_2 - T_1}{L}$

$P = e\sigma A T^4$

$W_{on\ gas} = -P\Delta V$ (constant pressure)

$U = \frac{3}{2}nRT = \frac{3}{2}Nk_B T$ (monatomic ideal gas)

Definition: $e = \frac{|W_{net}|}{Q_{added}} = 1 - \frac{Q_c}{Q_h}$

Carnot Theorem: $e_{max} = 1 - \frac{T_c}{T_h}$

To be memorized

New for exam 4

Definition: $\rho = \frac{m}{V}$

Definition: $P = \frac{F}{A}$

Archimedes' Principle: $F_B = w_{displaced\ fluid}$
$= m_{displaced\ fluid} \times g = \rho_{fluid} V_{object} g$

Ideal Gas Law $PV = nRT = Nk_B T$

Calorimetry: $Q = mc\Delta T$; $Q = mL$

First Law of Thermodynamics: $\Delta U = Q_{added} + W_{on\ system}$

Definition: isothermal = no temperature change

Definition: adiabatic = no heat exchanged

Cycles: $\Delta U = 0$; $|W_{net}| = Q_{added} - Q_{exhausted} = Q_h - Q_c$

Exam 4 - Review of important concepts

Bold = something that must be memorized

1. Pressure
   a. Definition: **P = F/A**
   b. Stress & strain of solids
   c. Increase with depth in a liquid: $P = P_{surface} + \rho gh$
   d. Pascal's principle: pressure in fluid the same at same h
   e. Archimedes' Principle: **F_B = weight of displaced fluid** (= …)

2. Fluid dynamics
   a. Viscosity
   b. Equation of continuity: $A_1v_1 = A_2v_2$
      i. Why/when true
   c. Bernoulli effect: motion of fluid causes P to decrease
      i. wings: air deflection helps, Bernoulli helps
   d. Bernoulli eqn: $P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

3. Temperature effects
   a. Thermal expansion of solids: $\Delta L = \alpha L_o \Delta T$
   b. Ideal gas law: **$PV = Nk_BT$**; **$PV = nRT$**

c. Average kinetic energy of gas: $\frac{1}{2}m{v_{ave}}^2 = \frac{3}{2}k_B T$

i. Relationship to internal energy, U = 3/2 nRT for monatomic ideal gas

4. Heat

a. Calorimetry: $\mathbf{Q = mc\Delta T}$; $\mathbf{Q = mL}$

b. Radiation: $P = e\sigma AT^4$ (both heat absorbed & emitted)

c. Conduction: $\frac{\Delta Q}{\Delta T} = kA\frac{T_2 - T_1}{L}$

d. Convection: qualitative only

5. Thermodynamics

a. P-V diagrams

i. Isothermal contours

ii. Types of state changes: constant P, constant V, constant T (**ΔU=0**), adiabatic (**Q=0**), cycle (**ΔU=0**)

b. Work done on/by a gas: **area under curve on P-V**

i. Positive vs. negative

c. First Law: $\mathbf{\Delta U = Q_{added} + W_{on\ system}}$

d. Engines: general picture

i. $\mathbf{Q_h = |W_{net}| + Q_c}$

ii. Efficiency: $e = \frac{|W_{net}|}{Q_{added}} = 1 - \frac{Q_c}{Q_h}$; $e_{\max} = 1 - \frac{T_c}{T_h}$

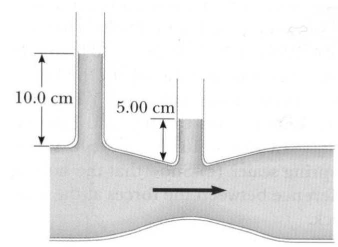
HW 17, Problem 2 (287 correct)

A container is filled to a depth of 20.0 cm with water. On top of the water floats a 44.1-cm-thick layer of oil with specific gravity 0.700. What is the absolute pressure at the bottom of the container? Assume that the atmospheric pressure is 1.00 Atm.

Answer: 106285 Pa

HW 18, Problem 4 (197 correct)

The inside diameters of the large portions of the horizontal pipe in the figure are 2.50 cm. Water flows to the right at a rate of 1.83E-04 m^3/s. Determine the inside diameter of the constriction.



Answer: 0.0148 m

HW 19, Problem 2 (282 correct)

A pair of eyeglass frames are made of epoxy plastic (coefficient of linear expansion =134 × 10^{-6} °C^{-1}). At room temperature (21.9 °C) the frames have circular lens holes 2.232 cm in radius. To what temperature must the frames be heated in order to insert lenses 2.252 cm in radius?

Answer: 88.8°C

More Sample Exam Problems (answers at end)

Problem 1. You are at the bottom of a lake in a submarine. The air pressure at the surface of the lake is 1 atm. The absolute pressure at the bottom is 6 atmospheres. The depth of the lake is [1]_______m. The force of the water on a submarine porthole of radius 4 cm is [2]________ N.

Problem 2. An ideal (Carnot) heat engine takes heat from water always at 100°C in a natural hot spring under the ground (geothermal energy), and generates useful work (electricity). It exhausts the waste heat to the air above the ground. The engine will be the most efficient in [3?]_____ . 1) Summer 2) Winter 3) neither; always the same. If the outside temperature is 30°C, and 2000 J is taken from the hot water, the heat exhausted to the air must be [4] _________ J

Problem 3. A solid iron sphere of volume 8 m^3 is totally submerged in water at the bottom of a pond. The density of iron is 8000 kg/m^3. The bouyant force on the sphere is [5]_____ N. The weight of the sphere is [6]______ N. To lift the sphere with a cable will require a minimum cable force of [7]_____ N.

Problem 4. When a spinning "curve" ball is thrown, it will tend to curve because of [8?]____ 1) the Bernoulli effect
2) conservation of angular momentum 3) Newton's 3rd law
4) the torque applied

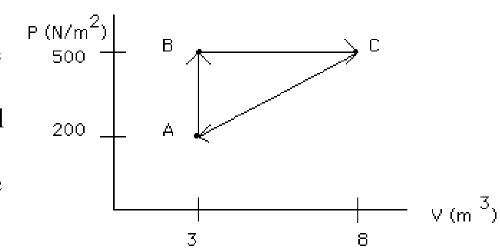
Problem 5. Cooled helium gas in a closed tank of volume 12 m^3 is at -100 °C, at one atm pressure. If the tank is cooled further to -200 °C, the pressure in the tank will be [9] ______ atmospheres.

The number of molecules in the gas is [10]______ molecules. The average kinetic energy of a molecule at -100°C is [11] ________ J.

Problem 6. A contraption allows you to narrow a region of a hose as water is flowing through it. The water is initially flowing through at a speed of 1.5 m/s. If the hose is narrowed in a region from a diameter of 2.5 cm to a diameter of 2.0 cm, what will be the speed of the water in the narrowed region? [12] ________ m/s. The pressure in the narrowed region will be [13?] _______ 1) the same as 2) less than 3) greater than the pressure in the region of hose just before the narrowing.

Problem 7. A 5 kg book falls onto the floor from a shelf 3 m above the floor. The entropy change in the universe was [14]_______1) positive 2) negative 3) zero.

Problem 8. One mole of a monatomic ideal gas is taken around the cycle shown.



In the process B→C, the change in the internal energy was [15]__________ J, and it was [16?] ________ 1) positive 2) negative 3) zero

In the process B→C, the heat exchanged was [17] __________J, and it was going [18?] ____________ 1) into 2) out of 3) neither the gas.

For the whole cycle, the net work done on the gas was [19] _____________ J, and was [20?] ____________ 1) positive 2) negative 3) zero. The heat exchanged for the cycle was [21] ______________ J, and it was going ___________[22?] 1) into 2) out of 3) neither the gas.

Problem 9. You have a pool of hot lava at 2500 °C in your backyard. You decide to stir it with a steel rod, which has a diameter of 2 cm. You need to choose the length of the rod to be long enough so that you don't burn your hand, which is at 30 °C. If you want the heat flow rate from the rod into your skin to be only 20 Watts, you should choose a rod of length [23] _______ m. (The thermal conductivity of steel is 80 W/m·°C.)

(Note: actual exam will be ~32 answer blanks)

Answers to "More Sample Exam Problems"

→ Not guaranteed (I didn't double-check my work)
Bonus points for the first people to find errors

1) 1 (51.68 m)
2) 0 (3055 N)
3) 2 (Winter)
4) 6 (1625 J)
5) 8 (78400 N)
6) 2 (627200 N)
7) 4 (548800 N)
8) 1 (Bernoulli effect)
9) 2 (0.422 atm)
10) 0 (5.087E26)
11) 5 (3.584E-21 J)
12) 3 (2.344 m/s)
13) 2 (less than)
14) 1 (positive)
15) 7 (3750 J)
16) 1 (positive)
17) 2 (6250 J)
18) 1 (into)
19) 5 (-750 J)
20) 2 (negative)
21) 5 (750 J)
22) 1 (into)
23) 1 (3.179 m)