

Physics 105, sections 1 and 2**Exam 4**

Colton 2-3669

Please write your CID _____

3 hour time limit. One 3" × 5" handwritten note card permitted (both sides). Calculators permitted. No books.Fundamental constants:

$$g = 9.80 \text{ m/s}^2$$

$$G = 6.67 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$$

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

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

$$R = k_B \cdot N_A = 8.314 \text{ J/mol}\cdot\text{K} = 0.08206 \text{ liter}\cdot\text{atm/mol}\cdot\text{K}$$

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

Conversion factors

$$1 \text{ inch} = 2.54 \text{ cm}$$

$$1 \text{ m}^3 = 1000 \text{ L}$$

$$1 \text{ atm} = 1.013 \times 10^5 \text{ Pa} = 14.7 \text{ psi}$$

$$1 \text{ cal} = 4.186 \text{ J}$$

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

$$T_K = T_C + 273.15$$

Note: all material constants that you should need for the exam are given here (not in the problems).Material properties

Density of water: 1000 kg/m^3

Density of air: 1.29 kg/m^3

Young's modulus of steel: $20 \times 10^{10} \text{ N/m}^2$

Linear expansion coefficient of brass: $19 \times 10^{-6} /^\circ\text{C}$

Specific heat of water: $4186 \text{ J/kg}\cdot^\circ\text{C}$

Specific heat of ice: $2090 \text{ J/kg}\cdot^\circ\text{C}$

Specific heat of steam: $2010 \text{ J/kg}\cdot^\circ\text{C}$

Specific heat of aluminum: $900 \text{ J/kg}\cdot^\circ\text{C}$

Latent heat of melting (water): $33 \times 10^5 \text{ J/kg}$

Latent heat of boiling (water): $2.26 \times 10^6 \text{ J/kg}$

Thermal conductivity of aluminum: $238 \text{ J/s}\cdot\text{m}\cdot^\circ\text{C}$

Average molar mass of air molecules: 29 g/mole

Keep four significant digits throughout your calculations; do not round up to less than four. When data is given, assume it has at least four significant digits. For example "15 meters" means 15.00 meters.

You are strongly encouraged to **write your work on the exam pages and circle the correct answer**. Of course also **record your final answers on the bubble sheet**.

→Write your CID above upper right corner. Did you do this _____? You won't get your exam back without writing your CID.

Problem 1. A pressure sensor inside a tub of water is oriented to read the amount of pressure pushing *down* on it. How does the reading change when the sensor is turned upside-down (kept at the same height)?

- increases
- decreases
- stays the same

Problem 2. Which exerts more pressure on the ground, a 15000 pound elephant with *four* circular feet (each 12 inches in diameter), or a 150 pound clown standing on *two* stilts (each 2 inches in diameter)?

- elephant
- clown
- same

Problem 3. In the “collapsing can demo”, why did the can collapse when the air was pumped out?

- a. Too much sucking force pulling on the inside
- b. Too much pressure from air on the outside

Problem 4. How deep does a scuba diver have to dive before the pressure is 2 atm?

- a. Less than 6.8 m
- b. 6.8 - 7.8
- c. 7.8 - 8.8
- d. 8.8 - 9.8
- e. 9.8 - 10.8
- f. More than 10.8 m

Problem 5. A boat is on a lake. If an anvil (that sinks) is pushed from the boat into the water, will the overall water level of the lake rise, fall or stay the same? (compared to when the anvil was in the boat)

- a. rise
- b. fall
- c. stay the same

Problem 6. If a log (that floats) is pushed from the boat into the water, will the overall water level of the lake rise, fall or stay the same? (compared to when the log was in the boat)

- a. rise
- b. fall
- c. stay the same

Problem 7. You make a 50 kg canoe out of a rectangular form: 2.2 m long by 0.7 m wide by 0.6 m deep. Assuming it doesn't tilt over, how much weight can you put in the canoe before it sinks?

- a. Less than 830 kg
- b. 830 - 840
- c. 840 - 850
- d. 850 - 860
- e. 860 - 870
- f. 870 - 880
- g. More than 880 kg

Problem 8. The pressure above an airplane's wing is _____ the pressure below the wing. (The airplane is flying at a constant elevation.)

- a. larger than
- b. smaller than
- c. the same as

Problem 9. Which balloon will have the greatest relative change in volume when immersed in liquid nitrogen: one filled with helium, or one filled with air?

- a. helium
- b. air
- c. same change

Problem 10. Actual gases follow the ideal gas law to a good approximation:

- a. at high temperatures
- b. at low temperatures
- c. always

Problem 11. You mix some helium and neon gas together in the same container so they are at the same temperature. The average translational kinetic energy per helium atom is ____ the average kinetic energy per neon atom. (Neon atoms are more massive than helium atoms.)

- a. greater than
- b. less than
- c. equal to

Problem 12. The fact that desert sand is very hot in the day and very cold at night is evidence that sand has a

- a. low specific heat
- b. high specific heat

Problem 13. The first law of thermodynamics is a statement of:

- a. conservation of energy
- b. conservation of (regular) momentum
- c. conservation of angular momentum
- d. conservation of mass/volume
- e. none of the above

Problem 14. The 2nd law of thermodynamics is a statement of:

- a. conservation of energy
- b. conservation of (regular) momentum
- c. conservation of angular momentum
- d. conservation of mass/volume
- e. none of the above

Problem 15. It is possible to compress an ideal gas without increasing its temperature.

- a. true
- b. false

Problem 16. A 10.4 N weight hangs from a 2 m long, 3 mm diameter steel wire. How much does the wire stretch?

- a. Less than 0.011 mm
- b. 0.011 - 0.012
- c. 0.012 - 0.013
- d. 0.013 - 0.014
- e. 0.014 - 0.015
- f. More than 0.015 mm

Problem 17. In an experiment with a brass ball and ring, the ring is heated to allow the ball to pass through. If the ball is 1.0000 cm in diameter and the hole in the ring has a diameter of 0.9992 cm, how hot (ΔT) does the ring need to be heated?

- a. Less than 41° C
- b. 41 - 42
- c. 42 - 43
- d. 43 - 44
- e. 44 - 45
- f. 45 - 46
- g. More than 46° C

Problem 18. Water in a closed pipe (5 cm in radius) flows at a speed of 3 m/s. How long will it take for 5 m³ of water to flow past any point?

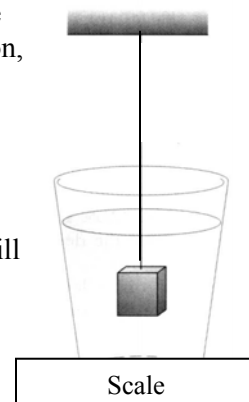
- a. Less than 130 s
- b. 130 - 150
- c. 150 - 170
- d. 170 - 190
- e. 190 - 210
- f. More than 210 s

Problem 19. An open beaker of water is resting on a spring scale. A hanging mass is immersed in the water. The reading on the scale will _____. (A free-body diagram will be required for this situation, in problem 32.)

- a. increase
- b. decrease
- c. stay the same

Problem 20. Same situation. The hanging mass is a 5 kg cube of metal, 10 cm on each edge. What will be the tension in the wire supporting the mass? (A free-body diagram will be required for this situation, in problem 32.)

- a. Less than 39.5 N
- b. 39.5 - 40.5
- c. 40.5 - 41.5
- d. 41.5 - 42.5
- e. 42.5 - 43.5
- f. 43.5 - 44.5
- g. More than 44.5 N



Problem 21. An old-fashioned 1 liter glass milk jug is “empty” (still has air inside), at 20° C. You seal it, then put it into a fire at 500° C. The jug does not burst. What is the final pressure in the jug?

- a. Less than 2.6 atm
- b. 2.6 - 2.7
- c. 2.7 - 2.8
- d. 2.8 - 2.9
- e. 2.9 - 3.0
- f. More than 3.0 atm

Problem 22. If instead of being totally empty the jug had one mole of water molecules in it (18 g), how much pressure would they exert after being vaporized? (The jug still does not break; neglect pressure from any air molecules left inside.)

- a. Less than 60 atm
- b. 60 - 61
- c. 61 - 62
- d. 62 - 63
- e. 63 - 64
- f. More than 64 atm

Problem 23. Water at 100° C is cooled to 0° C. The same amount of heat loss that it took to cool the ice could be used to freeze what percentage of the water?

- a. Less than 5%
- b. 5 - 7
- c. 7 - 9
- d. 9 - 11
- e. 11 - 13
- f. More than 13 %

Problem 24. What mass of steam that is initially at 120° C is needed to warm 1500 g of water in a light insulated container from 30° C to 45° C?

- a. Less than 28 g
- b. 28 - 30
- c. 30 - 32
- d. 32 - 34
- e. 34 - 36
- f. 36 - 38
- g. More than 38 g

For the next three problems, consider the cyclic process described by the figure.

Problem 25. For A to B: is $W_{\text{on gas}}$ positive or negative?

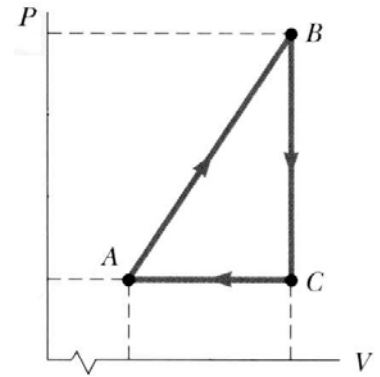
- a. positive
- b. negative
- c. neither ($W_{\text{on gas}} = 0$)

Problem 26. For C to A: does the internal energy increase or decrease?

- a. increase
- b. decrease
- c. neither ($\Delta U = 0$)

Problem 27. For B to C: is heat added or taken away from the gas? (Hint: think of the 1st Law.)

- a. added
- b. taken away
- c. neither ($Q_{\text{added}} = 0$)



Problem 28. You have 30 moles of a monatomic ideal gas at 400K. The gas expands from 1 m^3 to 3 m^3 in an *adiabatic* process; as the gas expands, the pressure decreases from 99.7 kPa to 15.98 kPa. How much work was done by the gas during the expansion? (Hint: start with the 1st Law.)

- a. Less than 66 kJ
- b. 66 - 68
- c. 68 - 70
- d. 70 - 72
- e. 72 - 74
- f. 74 - 76
- g. More than 76 kJ

Problem 29. A power plant has an electrical power output of 800 MW (M = “mega”, million) and operates with an efficiency of 35%. If the excess energy is carried away from the plant by a river with a mass flow rate of $2 \times 10^6 \text{ kg/s}$, what is the rise in temperature of the flowing water?

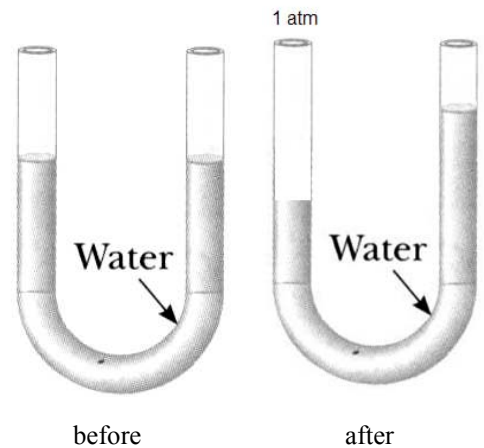
- a. Less than 0.16° C
- b. $0.16 - 0.18$
- c. $0.18 - 0.20$
- d. $0.20 - 0.22$
- e. $0.22 - 0.24$
- f. $0.24 - 0.26$
- g. More than 0.26° C

Problem 30. You very foolishly decide to build the walls of your new house out of solid aluminum, 5 cm thick. As a result, in the wintertime heat leaks out like a sieve. How much money does this cost you each *day*? The inside temp is 70° F (21.1° C), the average outside temperature is 25° F (-3.9° C), and your new house has a surface area of 280 m². The gas company charges you \$0.89 per “therm” (1.055×10^8 J). Ignore heat loss through the ground and through radiation & convection effects.

- a. Less than \$19,000
- b. \$19K - 20K
- c. \$20K - 21K
- d. \$21K - 22K
- e. \$22K - 23K
- f. \$23K - 24K
- g. \$24K - 25K
- h. More than \$25,000

Problem 31. A U-tube open at both ends is partially filled with water. Air is blown over the right end; this causes the water on the left to fall by 3 cm and the water on the right to rise by 3 cm. (That is, the total difference in height is now 6 cm.) The pressure at the left end stays at 1 atm. How fast was the air going over the right end? Note we have two densities here: water and air; don't get them confused in your equations.

- a. Less than 29 m/s
- b. 29 - 30
- c. 30 - 31
- d. 31 - 32
- e. 32 - 33
- f. 33 - 34
- g. 34 - 35
- h. More than 35 m/s



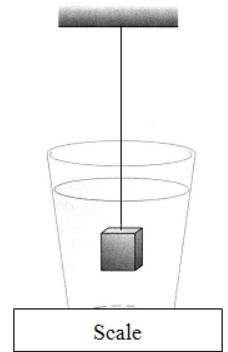
Write your CID separately on this sheet to guarantee your free body diagram doesn't get lost:

CID: _____

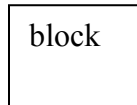
This problem is worth 4 pts; the rest of the exam is worth 96 points

Problem 32. For the situation of problems 19 and 20, draw free body diagrams for (a) the block, and (b) the cup of water.

In your diagrams, label the gravitational forces e.g. as " w_{object} " ("weight of object"). For all other forces, label what is producing the force and on what it is acting. Do so like this: use " $F_{1\text{on}2}$ " to mean "Force produced by object 1 acting on object 2", or e.g. " $N_{1\text{on}2}$ " for "normal force of object 1 on object 2".



(a) Free body diagram for block



(b) Free body diagram for cup of water

