Name: SOLUTIONS Student ID#_____ ID CODE A

Section #_____ TA Name_____

Fill in your name, student ID # (not your social security #), and section # (under ABC of special codes) on the Scantron sheet. Be sure to fill in the letter for the ID code on the upper right of this page for the first question. This determines which version of the test you took, and it is very important to get this correct. Make sure your exam has questions 2-21 and 6 total pages.

Physics 103 Midterm Exam 3 April 26, 2007

Multiple Choice, Closed Book

Circle the letter of the choice that best completes the statement or answers the question and also mark this answer on your Scantron sheet. You must do both.

Please be very careful with the first question:

1. ENTER THE ID CODE ABOVE IN THE UPPER RIGHT CORNER
   - **A.** ID Code A
   - **B.** ID Code B
   - **C.** ID Code C
   - **D.** ID Code D
   - **E.** ID Code E

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2. A copper wire of length 2.0 m, cross sectional area 7.1×10^{-6} m^2 and Young's modulus 11×10^{10} N/m^2 has a 200-kg load hung on it. What is its increase in length? ($g = 9.8$ m/s^2)

a. 0.50 mm
b. 1.0 mm
c. 2.5 mm
(d) 5.0 mm
e. 10. mm

$$\frac{F}{A} = Y\frac{\Delta L}{L}$$

$$\Delta L = FL/AY = mgL/AY$$

$$= \frac{200 \times 9.8 \times 2}{7.1\times10^{-6}\times11\times10^{10}} = 5.02\times10^{-3}\,m$$

3. The bulk modulus of a material, as a meaningful physical property, is applicable to which of the following?

a. only solids
b. only liquids
c. only gases
d. liquids and gases
(e) solids, liquids and gases

Any material will change volume with changing pressure.

4. How deep under the surface of a lake would the pressure be double that at the surface? (1 atm = 1.01×10^5 Pa, density water = 1000kg/m^3)

a. 1.00 m
b. 9.80 m
c. 2.00 m
(d) 10.3 m
e. 32.2 m

$$P = P_a + \rho gh = 2P_a$$

$$h = P_a/\rho g = 1.01\times10^5/1000\times9.8$$

$$= 10.3\,m$$

5. A blimp is filled with 400 m^3 of helium. How big a payload can the balloon lift? (The density of air is 1.29 kg/m^3; the density of helium is 0.18 kg/m^3.)

a. 111 kg
b. 120 kg
c. 129 kg
d. 215 kg
(e) 444 kg

$$B = mg = (\rho_a - \rho_{He})Vg$$

$$m = (\rho_a - \rho_{He})V$$

$$= (1.29 - 0.18)\times400$$

$$= 444\,kg$$

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6. Water (density = 1.0×10^3 kg/m^3) flows at 15 m/s through a pipe with radius 0.040 m. The pipe goes up to the second floor of the building, 3.0 m higher, and the pressure remains unchanged. What is the speed of the water flow in the pipe on the second floor?

a. 10 m/s
(b) 13 m/s
c. 14 m/s
d. 15 m/s
e. 16 m/s

$$v^2 = v_0^2 - 2gh$$
$$v = \sqrt{v_0^2 - 2gh}$$
$$= \sqrt{225 - 2 \times 9.8 \times 3} = 12.89 \text{ m/s}$$

7. A rectangular steel plate with dimensions of 30 cm × 25 cm is heated from 20°C to 220°C. What is its change in area? (Coefficient of linear expansion for steel is 11×10^{-6}/C°.)

a. 0.82 cm^2
b. 1.65 cm^2
(c) 3.3 cm^2
d. 6.6 cm^2
e. 33 cm^2

$$\Delta A = 2\alpha A_0 \Delta T$$
$$= 2 \times 11 \times 10^{-6} \times 30 \times 25 \times 200$$
$$= 3.3 \text{ cm}^2$$

8. What happens to its moment of inertia when a steel disk is heated?

(a) It increases.
b. It decreases.
c. It stays the same.
d. It decreases for half the temperature increase and then increases for the rest of the temperature increase.
e. It increases for half the temperature increase and then decreases for the rest of the temperature increase.

$I \propto mr^2$ mass stays the same
radius increases

9. A helium-filled weather balloon has a 0.90 m radius at liftoff where air pressure is 1.0 atm and the temperature is 298 K. When airborne, the temperature is 210 K, and its radius expands to 3.0 m. What is the pressure at the airborne location?

Number of moles (or molecules) is constant

a. 0.50 atm
b. 1.0 atm
c. 0.013 atm
(d) 0.019 atm
e. 0.38 atm

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$
$$P_2 = P_1 \frac{V_1}{V_2} \frac{T_2}{T_1} = P_1 \left(\frac{r_1}{r_2}\right)^3 \frac{T_2}{T_1} = \left(\frac{0.9}{3}\right)^3 \frac{210}{298}$$
$$= 0.019 \text{ atm}$$

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10. Two one-liter containers each contain 10 moles of a gas. The temperature is the same in both containers. Container A holds helium (molecular mass = 4 u), and container B holds oxygen (molecular mass = 16 u). Which container has the higher pressure and by what factor?

a. Container A has 8 times the pressure of container B.
b. Container A has 4 times the pressure of container B.
c. Container A has 2 times the pressure of container B.
d. Both containers have the same pressure.
e. More information is needed to answer this question.

$PV = nRT$

V, n, R, T are same

$\Rightarrow P$ is the same

11. For an ideal gas of a given mass, if the pressure remains the same and the volume increases:

a. the average kinetic energy of the molecules decreases.
b. the average kinetic energy of the molecules stays the same.
c. the average kinetic energy of the molecules increases.
d. Nothing can be determined about the molecular kinetic energy.
e. This process cannot happen.

$PV = nRT$

$V \propto T \propto \overline{KE}$

12. A 120-g block of hot copper is placed into a beaker of negligible heat capacity containing 300 g of water. The water temperature rises from 15°C to 35°C. Given $c_{Cu} = 0.10$ cal/g·°C, and $c_{water} = 1.00$ cal/g·°C, what was the original temperature of the hot copper block?

a. 500°C
b. 360°C
c. 720°C
d. 180°C
e. 535°C

$$m_{Cu} C_{Cu} (T - 35) = m_W C_W (35 - 15)$$

$$T = 35 + \frac{m_W C_W}{m_{Cu} C_{Cu}} (35 - 15)$$

$$= 35 + \frac{300 \times 1}{120 \times 0.1} \times 20 = 535^\circ C$$

13. Which of the following best describes a substance in which the temperature remains constant while at the same time it is experiencing an inward heat flow?

a. vapor
b. gas
c. liquid
d. solid

} inward heat causes temperature rise

e. substance undergoing a change of state

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14. In cloud formation, water vapor turns into water droplets which get bigger and bigger until it rains. This will cause the temperature of the air in the clouds to:

(a) get warmer. Energy lost by water heats the air
b. get cooler.
c. will not affect the temperature of the air in the clouds.
d. There is no air in clouds.
e. There is not enough information given to answer the question.

15. How much heat energy is required to vaporize a 1.0-g ice cube at 0°C? The heat of fusion of ice is 80 cal/g. The heat of vaporization of water is 540 cal/g, and c_{water} = 1.00 cal/g·°C.

a. 620 cal
(b) 720 cal
c. 820 cal
d. 410 cal
e. 1000 cal

$$Q = m(C_F + 100C + C_V)$$
$$= 1 \times (80 + 100 + 540)$$
$$= 720 \text{ cal}$$

16. A 2.0-m^2 window is constructed, using two layers of glass 4.0 mm thick, separated by an air space of 5.0 mm. If the temperature difference is 20 C° from the inside of the house to the outside air, what is the rate of heat flow through this window? (Thermal conductivity for glass is 0.84 J/s·m·°C and for air 0.0234 J/s·m·°C.)

a. 7700 W
b. 1900 W
c. 1000 W
d. 547 W
(e) 180 W

$$P = \frac{Q}{\Delta t} = \frac{A(T_H - T_C)}{L_1/k_1 + L_2/k_2}$$
$$= \frac{2 \times 20}{0.008/0.84 + 0.005/0.0234}$$
$$= 179 \text{ W}$$

17. According to the first law of thermodynamics, the sum of the heat gained by a system and the work done on that same system is equivalent to which of the following?

a. entropy change
(b) internal energy change → $\Delta U = Q + W$
c. temperature change
d. specific heat
e. None of the above

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18. A cylinder containing an ideal gas has a volume of 2.0 m^3 and a pressure of 1.0×10^5 Pa at a temperature of 300 K. The cylinder is placed against a metal block that is maintained at 900 K and the gas expands as the pressure remains constant until the temperature of the gas reaches 900 K. The change in internal energy of the gas is $+6.0 \times 10^5$ J. How much heat did the gas absorb?

a. 0
b. 2.0×10^5 J
c. 4.0×10^5 J
d. 6.0×10^5 J
(e) 10×10^5 J

$$Q = \Delta U - W = \Delta U + P\Delta V$$
$$= \Delta U + P V_1 \Delta T / T_1$$
$$= 6 \times 10^5 + 10^5 \times 2 \times 600/300$$
$$= 10 \times 10^5 \text{ J}$$

19. A heat engine receives 6 000 J of heat from its combustion process and loses 4 000 J through the exhaust and friction. What is its efficiency?

(a) 33%
b. 40%
c. 67%
d. 73%
e. 100%

$$e = \frac{W}{Q_H} = \frac{Q_H - Q_C}{Q_H} = 1 - \frac{Q_C}{Q_H}$$
$$= 1 - \frac{4000}{6000} = 1/3$$

20. The maximum theoretical thermodynamic efficiency of a heat engine operating between hot and cold reservoirs is a function of which of the following?

a. hot reservoir temperature only
b. heat transferred from the hot reservoir
c. cold reservoir temperature only
(d) both hot and cold reservoir temperatures
e. None of the above choices are valid.

$$e = 1 - \frac{Q_C}{Q_H} = 1 - \frac{T_C}{T_H}$$

21. One kilogram of water at 1.00 atm at the boiling point of 100°C is heated until all the water vaporizes. What is its change in entropy? (For water, $L_v = 2.26 \times 10^6$ J/kg)

a. 12100 J/K
(b) 6060 J/K
c. 3030 J/K
d. 1220 J/K
e. None of the above

$$\Delta S = Q/T = mL_v/T$$
$$= 1 \times 2.26 \times 10^6 / 373$$
$$= 6059 \text{ J/K}$$