Physics 103 Exam 3

Name DEL ID#________

Section #________ TA Name ________

Fill in the information on the scantron sheet. Use your student ID # and not your social security #. Fill the letters given for the first 5 questions on the scantron sheet. These letters determine which version of the test you took and are IMPORTANT to get right.

1. B

2. E

3. C

4. D

5. A

6. In an elastic solid there is a direct proportionality between strain and:

a. elastic modulus
(b.) stress
c. temperature
d. cross-sectional area
e. density

7. The quantity "strain" expressed in terms of the fundamental quantities (mass, length, time) is equivalent to:

a. MLT^{-1}
b. $ML^{-1}T^{-2}$
c. $M^2L^{-1}T^{-3}$
(d.) a dimensionless quantity
e. L^3

$\frac{\Delta L}{L}$, $\frac{\Delta V}{V}$, $\frac{\Delta x}{h}$

8. By what factor is the total pressure greater at a depth of 850 m of water than at the surface where the pressure is one atmosphere?

a. 100
b. 19
(c.) 84
d. 74
e. 190

$P = \rho g h + 1\,atm = \left(1000\,\frac{kg}{m^3}\right)\left(9.8\,\frac{m}{s^2}\right)(850\,m) + 1.013\times10^5\,Pa$ ($N/m^2 = Pa$)

$P = 8.33\times10^6 + 1.01\times10^5 = 8.43\times10^6\,Pa$

$\frac{P}{1\,atm} = \frac{8.43\times10^6}{1.013\times10^5} = 83.2$

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9. A fountain sends water to a height of 100 meters. What must be the pressure (above atmospheric) of the underground water system?

a. 1 ATM
b. 9.7 ATM
c. 4.2 ATM
d. 7.2 ATM
e. 10.7 ATM

$P = \rho g h + 1\ ATM = 1000(9.8)(100) + 1\ ATM$

$\Delta P = P - 1\ ATM = 9.8 \times 10^5\ Pa / 1.01 \times 10^5 \frac{Pa}{ATM}$

$\Delta P = 9.67\ ATM$

10. Which best expresses the value for the coefficient of volume expansion, β for given material as a function of its corresponding coefficient of linear expansion, α?

a. $\beta = \alpha^3$
b. $\beta = 3\alpha$
c. $\beta = 2\alpha$
d. $\beta = \alpha$
e. $\beta = \alpha^2$

11. If the temperature of an ideal gas contained in a box is increased:

a. the average velocity of the molecules in the box will be increased. $\bar{V} = 0$
b. the number of molecules in the box will be increased. NO
c. the average speed of the molecules in the box will be increased. YES ←
d. the distance between molecules in the box will be increased. NO (SAME DENSITY)
e. the average time between collisions will be increased. DECREASED (FASTER MOLECULES)

12. A 10 g piece of aluminum (which has a specific heat of 0.215 cal/gm-°C) is warmed so that its temperature increases by 5°C. How much heat was transferred into it?

a. 11 cal
b. 48 cal
c. 22 cal
d. 34 cal
e. 54 cal

$\Delta Q = m C \Delta T = 10\,gm \left(0.215 \frac{CAL}{gm\,°C}\right) 5\,°C$

$= 10.75\ CAL$

13. Heat flow occurs between two bodies in thermal contact when they differ in what property?

a. mass
b. temperature
c. specific heat
d. density
e. heat capacity

14. Which one of the following processes occur only in a fluid?

a. conduction — GAS, LIQUID, SOLID
b. compression
c. radiation — ANYWHERE
(d) convection ← GAS, LIQUID (BOTH ARE FLUIDS)
e. evaporation — LIQUID, SOLID

15. A window pane is half a centimeter thick and has an area of 1 m^2. The temperature difference between the inside and outside surfaces of the pane is 15°C. What is the rate of heat flow through this window? (Thermal conductivity for glass is 0.8 J/s-m-°C.)

a. 48,000 J/s
b. 500 J/s
(c.) 2,400 J/s
d. 1,000 J/s
e. 4,800 J/s

$$\frac{\Delta Q}{\Delta t} = \frac{kA\Delta T}{L} = \frac{0.8 \frac{J}{s\,m\,°C}(1\,m^2)\,15\,°C}{0.5\times10^{-2}\,m} = 2400\,\frac{J}{s}$$

16. A swimming pool heater has to be able to raise the temperature of the 40,000 gallons of water in the pool by 10°C. How many kiloWatthours of energy are required? (One gallon of water has a mass of approximately 3.8 kg and the specific heat of water is 4186 J/kg-°C.)

a. 1955 kWh
b. 216 kWh
(c.) 1770 kWh
d. 330 kWh
e. 180 kWh

$$1\,kWh = 1000\,\frac{J}{s} \times 3600\,s = 3.6\times10^6\,J$$

$$\Delta Q = mC\Delta T = (40000)(3.8)(4186)(10)$$

$$\Delta Q = 6.36\times10^9\,J / (3.6\times10^6\,J/kWh) = 1767\,kWh$$

17. Iced tea is made by adding ice to 1.8 kg of hot tea, initially at 80°C. How many kg of ice, initially at 0°C, are required to bring the mixture to 10°C? (L_f = 80 kcal/kg)

a. 1.8 kg
b. 1.2 kg
c. 1.6 kg
(d.) 1.4 kg
e. 1.5 kg

$$\Delta Q_{ICE} = m_{ICE} L_f + m_{ICE} C_{WATER} \underbrace{(T_f - T_{ICE})}_{\Delta T_{ICE}}$$

$$\Delta Q_{TEA} = m_{TEA} C_{TEA} (T_f - T_{TEA})$$

$$\Delta Q_{ICE} + \Delta Q_{TEA} = 0$$

$C_{WATER} = C_{TEA} = 1$ kcal/kg SO

$$m_{ICE}[80 + 1(10°C - 0°C)] + 1.8(1)(10°C - 80°C) = 0$$

$$m_{ICE} = (1.8)(1)(+70) / [80+10] = 1.8\left(\frac{7}{9}\right) = 1.4\,kg$$

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18. A 5 gram lead bullet traveling in 20°C air at 300 m/s strikes a flat steel plate and stops. What is the final temperature of the lead bullet? (Assume all heat is retained by the bullet). The melting point of lead is 327°C. The specific heat of lead is 0.122 J/g/°C and the heat of fusion of lead is 24.7 J/g.

a. 227°C
(b.) 327°C
c. 260°C
d. 293°C
e. 300°C

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(.005)(300)^2 = 225\ J$

$\Delta Q = 225\ J = mc\Delta T$

$\Delta T = 225/(mc) = 225/(5)(0.122) = 369\ °C$ (SEE BELOW)

19. The tungsten filament of a lightbulb has an operating temperature of about 1800°C. If the emitting area of the filament is 1 cm^2, and its emissivity is 0.68, what is the power output of the lightbulb? ($\sigma = 5.67 \times 10^{-8}\ W/m^2K^4$)

a. 100 W
b. 40 W
(c.) 70 W
d. 60 W
e. 150 W

$P = \sigma A e(T^4 - T_0^4)$ T_0 IS ~293K (ROOM TEMP.) AND FOURTH POWERS WILL MAKE IT TOO SMALL TO CONSIDER, SO

$P = \sigma A e T^4 = 5.67\times10^{-8}(.01\ m)^2(.68)(1800+273)^4 = 71.2\ W$

20. In an isothermal process for an ideal gas system (where the internal energy doesn't change), which of the following choices best corresponds to the value of the work done by the system?

(a.) its heat intake
b. twice the negative of its heat intake
c. twice its heat intake
d. the negative of its heat intake
e. half the heat intake

ISOTHERMAL $\Rightarrow \Delta T = 0$

$U = \frac{3}{2}Nk_BT$ SO $\Delta U = 0$

$\Delta U = Q - W = 0 \Rightarrow \underline{Q = W}$

21. A heat engine exhausts 3000 J of heat while performing 1500 J of of useful work. What is the efficiency of the engine?

a. 15%
b. 60%
(c.) 33%
d. 50%
e. 67%

HEAT INPUT MUST HAVE BEEN 1500 + 3000

EFFICIENCY $= W/Q_{IN} = 1500/4500$

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18 (CONTINUED) 369° WILL RAISE THE LEAD ABOVE ITS MELTING POINT, 327°, BUT WHILE IT IS MELTING IT WILL STAY AT 327°. THE ANSWER IS THEN 327° OR HIGHER, BUT 327° IS THE HIGHEST AVAILABLE. (IN FACT, THERE IS NOT ENOUGH ENERGY TO MELT THE WHOLE 5 gm)

22. A 5 mole ideal gas system undergoes an adiabatic expansion, while cooling from 80°C to 60°C. How much work is done by the system during this expansion? (R = 8.31 J/mol-K)

   a. -1250 J
   b. +1250 J
   c. -41 J
   d. zero
   e. +41 J

$U = \frac{3}{2} N k_B T = \frac{3}{2} nRT \Rightarrow \Delta U = \frac{3}{2} nR\Delta T$

ADIABATIC $\Rightarrow Q = 0$; $\Delta U = Q - W = -W$

$\Delta U = \frac{3}{2}(5)(8.31)(-20°C) = -1246$ J; $W = -\Delta U$

23. One kilogram of water at the 1 ATM boiling point (100°C) is heated until all the water vaporizes. What is its change in entropy? (For water, L_{vap} = 2.26 × 10[6] J/kg)

   a. 3030 J/K
   b. 2260 J/K
   c. 12118 J/K
   d. 1223 J/K
   e. 6059 J/K

$\Delta S = \Delta Q / T = m L_v / T$

$\Delta S = (1)(2.26 \times 10^6) / (100 + 273) = 6059 \frac{J}{K}$ (K)

24. When gasoline is burned, it gives off 46,000 J/gram of heat energy. If an automobile uses 13.0 kg of gasoline per hour with an efficiency of 21%, what is the average horsepower output of the engine? (1 HP = 746 W)

   a. 67.2 HP
   b. 223 HP
   c. 46.76 HP
   d. 33.6 HP
   e. 108.7 HP

$13\ kg \times 1000\ \frac{gm}{kg} \times 46000\ J/gm = 5.98 \times 10^8$ J

5.98×10^8 J / 3600 s = 1.66×10^5 W

1.66×10^5 W / 746 W/HP = 223 HP × 21% = 46.8 HP

25. A bottle with a fixed volume of 2 m³ contains an ideal gas at a pressure of 1 ATM at a temperature of 300°C. The bottle is placed against a metal block that is maintained at 900°C, and the gas comes to thermal equilibrium with the block. What is the pressure of the gas after equilibrium is reached?

   a. 3 ATM
   b. 5 ATM
   c. 1 ATM
   d. 4 ATM
   e. 2 ATM

$PV = nRT$

$V_f = V_i$

$T_f = 900°C$

$T_f = (900 + 273)K$

$T_i = 300°C$

$T_i = (300 + 273)K$

$\frac{P_f V_f}{T_f} = \frac{P_i V_i}{T_i} = nR$

$\frac{P_f}{P_i} = \frac{T_f}{T_i} \left(\frac{V_f}{V_i} \right) = 2.22$, where $\frac{V_f}{V_i} = 1$