6. A cabin has a 0.159 m thick wooden floor [k = 0.141 W/(m C°)] with an area of 13.4 m^2. A roaring fire keeps the interior of the cabin at a comfortable 18.0 °C while the air temperature in the crawl space below the cabin is -20.6 °C. What is the rate of heat conduction through the wooden floor?

__ A. 245 J/s
✓ B. 459 J/s
__ C. 31 J/s
__ D. 138 J/s
__ E. 214 J/s

$H = \frac{Q}{\Delta t} = kA\frac{T_2 - T_1}{L} = 0{,}141\ \frac{W}{m\,°C} \times \frac{13{,}4\ m^2 \times 38{,}6\ °C}{0{,}159\ m}$

$H = 458{,}7\ W \qquad 1\ W = 1\ J/s$

7. An ideal monatomic gas absorbs 750 J of heat as it performs 625 J of work. What is the resulting change in temperature if there are 1.3 moles of the gas?

✓ A. 7.7 K
__ B. —4.3 K
__ C. —8.6 K
__ D. 9.6 K
__ E. 23 K

$\Delta U = \Delta Q - W = 750 - 625 = 125\ J$

AVERAGE ENERGY PER ATOM $\frac{1}{2}m\overline{v^2} = \frac{3}{2}k_B T$ SO

FOR N ATOMS $U = \frac{3}{2}N k_B T$ AND

$\Delta U = \frac{3}{2}N k_B \Delta T \Rightarrow \Delta T = \frac{2}{3}\frac{\Delta U}{N k_B}$ $\qquad N = 1{,}3\ \text{MOLES} \times 6{,}02\times10^{23}/\text{MOLE}$

SO

$\Delta T = \frac{2(125\ J)}{3(1{,}3)\times 6{,}02\times10^{23} \times 1{,}38\times10^{-23}}$

$\Delta T = 7{,}72\ °K$

8. Which one of the following is *not* an example of convection?

__ A. An electric heater warms a room.
__ B. An eagle soars on an updraft of wind.
__ C. Smoke rises above a fire.
__ D. Water cooks spaghetti.
✓ E. A person gets a suntan on a beach. (RADIATION)

9. A 0.20-kg lead shot is heated to 90.0 °C and dropped into a beaker with 0.50 kg of water initially at 20.0 °C. What is the final equilibrium temperature of the lead shot? The specific heat capacity of lead is 128 J/(kg C°); and the specific heat of water is 4186 J/(kg C°). Assume the beaker is insulated so that no heat is lost to the room.

__ A. 42.1 °C
__ B. 22.4 °C
__ C. 27.8 °C
__ D. 4.8 °C
✓ E. 20.8 °C

$-Q_{WATER} = Q_{LEAD}$

$m_{WATER} C_{WATER} (T_f - T_{WATER}) = m_{LEAD} C_{LEAD} X$

$X(T_{LEAD} - T_f)$

$(0{,}50\ kg)(4186\ J/kg°)(T_f - 20)°$

$= (0{,}20)(128)(90 - T_f)$

$2093 T_f - 41860 = 2304 - 25{,}6 T_f$

$2118{,}6 T_f = 44164 \Rightarrow T_f = 20{,}85\ °C$

10. What are the SI units of the product of pressure and volume, *PV*?

✓ A. joule

__ B. newton second

__ C. newton

__ D. meter^2

__ E. kilogram meter/second

P UNITS ARE $P_a = \frac{N}{M^2}$

$[PV] = [P_a \cdot M^3] = \left[\frac{N}{M^2} M^3\right] = [N \cdot M]$

$1\ N \cdot M = 1$ JOULE (PV = WORK)

11. A string is wrapped around a pulley of radius 0.10 m and moment of inertia 0.15 kg m^2. The string is pulled with a force of 12 N. What is the magnitude of the resulting angular acceleration of the pulley?

__ A. 0.055 rad/s^2

__ B. 0.13 rad/s^2

__ C. 80 rad/s^2

✓ D. 8.0 rad/s^2

__ E. 18 rad/s^2

$\tau = I\alpha$ $\quad \tau = F\ell \sin\theta = (12\,N)(0.1\,M)(1)$

$I = 0.15\ kg\,m^2$

$\alpha = \frac{\tau}{I} = \frac{1.2\ N \cdot M}{0.15\ kg\,m^2} = 8.0\ \frac{kg\,M/s^2}{kg\,M} = 8.0\ \frac{(1\,RAD)}{s^2}$

12. How many molecules are in 0.064 kg of sulfur dioxide, SO_2? (atomic masses: S = 32 g/mol; O = 16 g/mol)

__ A. 2.00 x 10^{24}

__ B. 3

__ C. 64

✓ D. 6.02 x 10^{23}

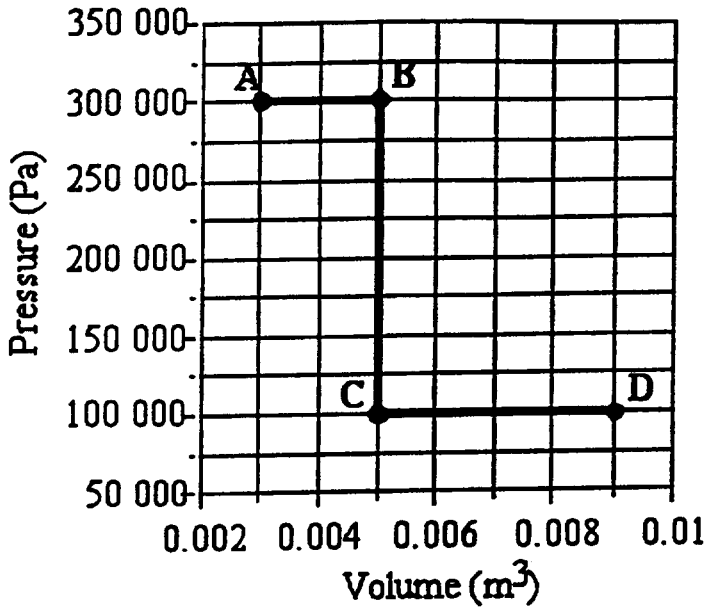
__ E. 3.85 x 10^{25}

MOLECULAR WEIGHT OF $SO_2 = 32 + 2(16) = 64\ g/MOL$

SO $0.064\ kg = 64\ g = 1$ MOLE OF SO_2

1 MOLE $\rightarrow 6.02 \times 10^{23}$ MOLECULES

13. Two moles of a confined ideal monatomic gas begin at state **A** in the pressure-volume graph and follow the path shown to state **D**. If the temperature of the gas at **A** is 54 K, what is the temperature of the gas at **D**?



✓ A. 54 K
__ B. 46 K
__ C. 60 K
__ D. 78 K
__ E. 32 K

$PV = nRT$ $\quad P_i V_i = 300000 \times .003 = 900$

$P_f V_f = 100000 \times .009 = 900$

PV AND n DID NOT CHANGE, SO

T DID NOT CHANGE.

14. A solid sphere rolls without slipping along a horizontal surface. What percentage of its total kinetic energy is rotational kinetic energy about the center of mass? The moment of inertia of a sphere about its center of mass is $(2/5)mr^2$.

__ A. 75 %
__ B. 50 %
__ C. 33 %
__ D. 12 %
✓ E. 29 %

FOR ROLLING WITHOUT SLIPPING

$v = \omega r$

$KE = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

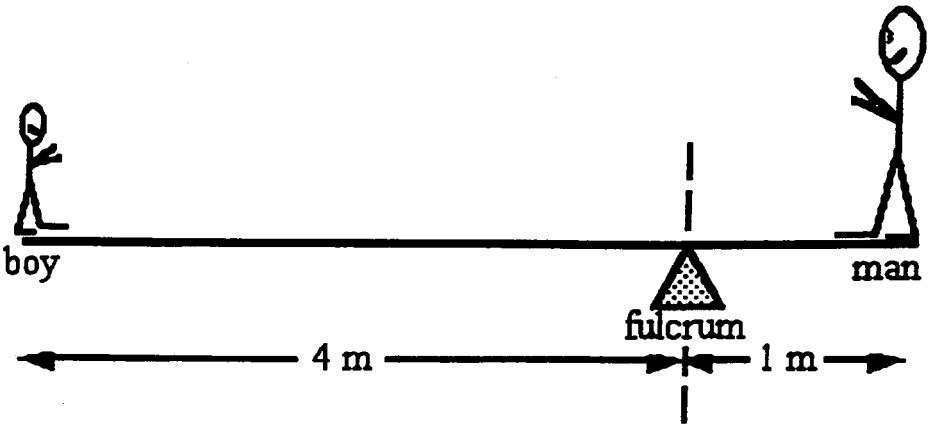
$= \frac{1}{2}m(r\omega)^2 + \frac{1}{2}\left(\frac{2}{5}mr^2\right)\omega^2$

$= \left(\frac{1}{2} + \frac{1}{5}\right)mr^2\omega^2 = 0.7\,mr^2\omega^2$

ROTATIONAL $KE = \frac{1}{5}mr^2\omega^2 = 0.2\,mr^2\omega^2$

ROTATIONAL/TOTAL $= 0.2/0.7 \rightarrow 29\%$

An 80-kg man balances the boy on a teeter-totter as shown. **Note:** *Ignore the weight of the board.*



15. What is the approximate mass of the boy? TORQUES MUST BE EQUAL

__ A. 50 kg
__ B. 45 kg
✓ C. 20 kg
__ D. 40 kg
__ E. 10 kg

$m_{MAN} g (1M) = m_{BOY} g (4m)$

$m_{BOY} = \frac{1}{4} m_{MAN} = 20\ kg$

16. A child standing on the edge of a freely spinning merry-go-round moves quickly to the center. Which one of the following statements is necessarily true concerning this event and why?

__ A. The angular speed of the system decreases because the moment of inertia of the system has decreased.
__ B. The angular speed of the system decreases because the moment of inertia of the system has increased.
__ C. The angular speed of the system increases because the moment of inertia of the system has increased.
X D. The angular speed of the system increases because the moment of inertia of the system has decreased. LIKE PULLING IN YOUR ARMS WHILE SPINNING
__ E. The angular speed of the system remains the same because the net torque on the merry-go-round is zero.

17. A metal rod 40.0000 cm long at 40 °C is heated to 60 °C. The length of the rod is then measured to be 40.0105 cm. What is the coefficient of linear expansion of the metal?

__ A. $44 \times 10^{-6}/C°$
__ B. $53 \times 10^{-6}/C°$
__ C. $22 \times 10^{-6}/C°$
__ D. $71 \times 10^{-6}/C°$
✓ E. $13 \times 10^{-6}/C°$

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

$\alpha = \frac{\Delta L}{L_0 \Delta T} = \frac{.0105\ cm}{(40\ cm)(20\ °C)}$

$\alpha = 1.31 \times 10^{-5}/°C$

18. Calculate the rms speed of a monatomic ideal gas of temperature 5.00 °C. The molecular weight of the gas is 32 g/mole.

$5°C = 278°K$

✓ A. 465 m/s
__ B. 328 m/s
__ C. 86.3 m/s
__ D. 62.0 m/s
__ E. 487 m/s

$\frac{1}{2} m\overline{v^2} = \frac{3}{2} k_B T \Rightarrow \overline{v^2} = 3k_B T/m$

$m = 32g/6.02\times10^{23}$

$\overline{v^2} = \frac{3(1.38\times10^{-23})\,278\,°K}{(.032kg/6.02\times10^{23})} = 2.165\times10^5$

$v_{RMS} = \sqrt{\overline{v^2}}$

$v_{RMS} = 4.65\times10^2$

19. A person steps out of the shower and dries off. The person's skin with an emissivity of 0.70 has a total area of 1.2 m² and a temperature of 33 °C. What is the net rate at which energy is lost to the room through radiation by the naked person if the room temperature is 24 °C?

__ A. 25 W
✓ B. 47 W
__ C. 81 W
__ D. 67 W
__ E. 0.041 W

$P_{NET} = \sigma A e (T^4 - T_0^4)$

$P_{NET} = 5.67\times10^{-8}\times1.2\times0.70\left((273+33)^4 - (273+24)^4\right)$

°C TO °K

$P_{NET} = 47.0\ W$

20. A fixed amount of ideal gas is compressed isothermally. Which entry in the table below correctly depicts the sign of the work done, the change in the internal energy, and the heat exchanged with the environment?

	work done	*change in internal energy*	*heat exchanged*
✓ A.	negative	zero	negative
__ B.	negative	negative	zero
__ C.	negative	zero	positive
__ D.	positive	zero	positive
__ E.	positive	negative	zero

$W = P\Delta V$

$\Delta V < 0$

SO $W < 0$

$\Delta T = 0$ (ISOTHERMAL)

SO $\Delta U = 0$

$\Delta U = Q - W = 0$

$Q = W < 0$

21. Argon gas at 305 K is confined within a constant volume at a pressure P_1. If the gas has a pressure P_2 when it is cooled to 195 K, what is the ratio of P_2 to P_1?

__ A. 1.28
__ B. 0.717
__ C. 0.410
✓ D. 0.639
__ E. 1.56

$PV = nRT \quad V_i = V_f$ CONST. VOLUME

$\frac{P_i V_i}{P_f V_f} = \frac{nRT_i}{nRT_f}$

SO $\frac{P_2}{P_1} = \frac{P_f}{P_i} = \frac{T_f}{T_i} = \frac{195}{305} = 0.6393$

22. A thermos bottle contains 3.0 kg of water and 2.0 kg of ice in thermal equilibrium at 0 °C. How much heat is required to bring the system to thermal equilibrium at 50 °C? The latent heat of vaporization is 22.6 x 10^5 J/kg and the latent heat of fusion is 33.5 x 10^4 J/kg.

__A. 1.3 x 10^6 J
✓ B. 1.7 x 10^5 J
__C. 2.3 x 10^6 J
__D. 1.0 x 10^6 J
__E. 1.1 x 10^7 J

FIRST MELT THE ICE $Q_M = mL = 2kg \times 3.33\times10^5 J/kg$

$Q_M = 6.66\times10^5 J$

NOW HEAT IT TO 50° C

$Q_H = mc\Delta T = (5kg)(4186 \frac{J}{kg\,°C})$ so &

$Q_H = 1.0465\times10^6 J$ $Q = Q_H + Q_M = 1.71\times10^6 J$

23. Which object will emit more electromagnetic radiation than it absorbs from its surroundings? WHICH IS HOTTER THAN ITS SURROUNDINGS?

✓ A. a 200 °C copper coin in a beaker of water at 98 °C
__B. a girl scout sitting close to a campfire
__C. an ice cube in thermal equilibrium with the interior of a freezer
__D. a 600 °C lead sphere in a 700 °C oven
__E. an ice cube in beaker of water at 50 °C

24. Three thermometers are placed in a closed insulated box and are allowed to reach thermal equilibrium. One is calibrated in Fahrenheit degrees, one in Celsius degrees, and one in Kelvins. The Celsius thermometer reads -40 °C and the Kelvin thermometer reads 233 K. Which one of the following statements is necessarily true?

__A. The Kelvin thermometer should read -233 K.
✓ B. The Fahrenheit thermometer must read -40 °F.
__C. If the temperature of the contents is increased by 10 C°, the reading on the Kelvin thermometer should increase by 273 K.
__D. The Kelvin thermometer should read -313 K.
__E. If water were found within the box, it must be in the liquid state.

$-40°F \Leftrightarrow -40C°$

$°F = (9/5)°C + 32 = \frac{9}{5}(-40) + 32$

$= -72 + 32$

$= -40$ ✓

25. A spinning skater draws in her outstretched arms thereby *reducing* her moment of inertia by a factor of 2. Determine the ratio of her final kinetic energy to her initial kinetic energy.

__A. 0.5
__B. 1
✓ C. 2
__D. 4
__E. 16

Iw IS CONSTANT

$I \times \frac{1}{2}$ SO $w \times 2$

INITIAL $KE = \frac{1}{2} I w^2$

FINAL $KE = \frac{1}{2}\left(\frac{1}{2}I\right)(2w)^2 = Iw^2$

TWICE THE INITIAL KE.