1. A ball is thrown up with an initial velocity of 7.67 m/s. Use the conservation of energy to find the maximum height that it reaches.
   - a. 0.8 m
   - b. 1.0 m
   - c. 1.25 m
   - [✓ d.] 3.0 m

$\frac{1}{2}mv^2 + mgh$

$\frac{1}{2}\frac{v^2}{g} = h$

2. A circus performer, the human cannon ball, is fired with an initial velocity of 10 m/s at an angle of 45 degrees and lands on a mat 15 m below the launch point. What is his speed just before he hits the mat?
   - a. 7.1 m/s
   - b. 14 m/s
   - c. 19 m/s
   - [✓ d.] 20 m/s

$\frac{1}{2}mv^2 + mgh = \frac{1}{2}mv^2$

$\frac{1}{2}10^2 + 9.8\ 15m = \frac{1}{2}v^2$

3. How much work is done on a 20 kg box when it's being pushed with an applied force of 30 N over a distance of 5 meters?
   - a. 0 J
   - b. 100 J
   - [✓ c.] 150 J
   - d. 600 J
   - e. 980 J
   - f. 3000 J

$W = F \cdot d$

$= 30 \cdot 5$

4. In perfectly elastic collisions
   - a. only momentum is conserved.
   - b. only kinetic energy is conserved.
   - [✓ c.] both momentum and kinetic energy are conserved.

5. In perfectly inelastic collisions
   - [✓ a.] only momentum is conserved.
   - b. only kinetic energy is conserved.
   - c. both momentum and kinetic energy are conserved.

6. When you lose 15 lbs, how did the largest fraction of the weight leave your body?
   - a. Urine
   - b. Solid waste
   - c. Sweat
   - d. Energy
   - e. Respiration – water vapor
   - [✓ f.] Respiration – carbon dioxide

7. Consider a giant oak tree. Where does the largest fraction of the dry mass of the tree come from?
   - a. Water
   - b. Minerals in the soil
   - c. Sun
   - d. Oxygen
   - [✓ e.] Carbon

8. Convert 300 °F to Celsius and Kelvin
   - a. 135 °C, 408 K
   - b. 149 °C, -124 K
   - [✓ c.] 149 °C, 422 K
   - d. 242 °C, 515 K
   - e. 572 °C, 299 K

$T_C = (T_F - 32)\,5/9$

9. How does -200 °C and -200 °F compare?
   - a. -200 °C > -200 °F
   - [✓ b.] -200 °F > -200 °C
   - c. -200 °C = -200 °F

100 — 212 Boiling
0 — 32 freezing
. — -132
-200 — -200

10. When the temperature of an ideal gas is increased, which of the following also increases? (1) The thermal energy of the gas; (2) the average kinetic energy of the gas; (3) the average potential energy of the gas; (4) the mass of the gas atoms; (5) the number of gas atoms.
    - a. 1, 2, and 3
    - [✓ b.] 1 and 2
    - c. 4 and 5
    - d. 2 and 3
    - e. All of 1–5

11. Two samples of ideal gas, sample 1 and sample 2, have the **same thermal energy**. Sample 1 has **twice as many atoms** as sample 2. What can we say about the temperatures of the two samples?
    - a. $T_1 > T_2$
    - b. $T_1 = T_2$
    - [✓ c.] $T_1 < T_2$

12. A one mole sample of Helium (6.647×10^{-27}kg) is at 20°C and is considered to behave ideally. What is the average kinetic energy per molecule?
    - a. 4.14×10^{-22} J
    - [✓ b.] 6.065×10^{-21} J
    - c. 353 J
    - d. 1351 J
    - e. 3652 J

$K = \frac{3}{2} k_B \overline{T}$

$= \frac{3}{2}\, 1.38 \times 10^{-23} \frac{J}{K}\ 293$

13. What is the rms speed of a helium molecule at room temperature? 20°C

    a. 4.14×10^{-22} m/s
    b. 6.065×10^{-21} m/s
    c. 353 m/s
    [✓ d.] 1351 m/s
    e. 3652 m/s

$K = \frac{1}{2}mv^2$ so $v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2 \cdot 6.065\times10^{-21}\,m/s}{6.647\times10^{-27}\,kg}}$

or $V_{rms} = \sqrt{\frac{3k_BT}{m}} = \sqrt{\frac{3 \; 1.38\times10^{-23}\,\frac{J}{K} \; 293}{6.647\times10^{-27}\,kg}}$

14. A concrete block is 3 m long, 0.5 meters high and 0.75 m wide during the hottest part of the day when it's 43°C. What is the change in length of the block when it is -7°C.

    a. 0.0003 m
    b. 0.00045 m
    [✓ c.] 0.0018 m
    d. 0.0020 m
    e. 0.012 m

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

$= 12\times10^{-6}\,\frac{1}{K} \; 3\,m \; -50 =$

$= -0.0018\,m$

15. A waterfall is 200 m high. If all the gravitational potential energy of the water were converted into thermal energy, by how much would the temperature of the water increase after hitting the water at the bottom of the falls?

    a. 0.1 degrees
    [✓ b.] 0.5 degrees
    c. 1 degree
    d. 5 degrees
    e. Not enough information

$Mgh = mc\Delta T$

$\frac{gh}{c} = \Delta T$

$\frac{9.8 \cdot 200m}{4186} = 0.468°C$

16. A 1500 kg car traveling at 30 m/s quickly brakes to a halt. The kinetic energy of the car is converted to thermal energy of the disk brakes. The brake disks (one per wheel) are iron disks with a mass of 4.0 kg. Estimate the temperature rise of each disk as the car stops.

    a. 5 °C
    b. 75 °C
    [✓ c.] 94 °C
    d. 376 °C

$K = Q$

$\frac{1}{2}mv^2 = 675,000J$

Per dsc: $168,750J = mc\Delta T$

$\frac{168,750J}{4kg \; 449} = 93.96$

17. An insulated container holds a combination of steam and water in thermal equilibrium at atmospheric pressure. What is the temperature of the water?

    a. 0 °C
    b. < 100 °C
    [✓ c.] 100 °C
    d. > 100 °C
    e. Not enough information

18. 50 g of ice at 0°C is added to 100 g of room temp water (20°C). The final temperature will be
    - a. < 0°C
    - [✓ b.] 0°C
    - c. between 0°C and 20°C
    - d. 20°C
    - e. not enough information

Melt ice $Q = mL = 0.05\,\text{kg} \cdot 3.33 \times 10^5 \frac{\text{J}}{\text{kg}} = 16,650\,\text{J}$

Cool water to 0°C $mc\Delta T = 0.1\,\text{kg}\ 4186\ 20 \approx 8,372\,\text{J}$

There is not enough energy available in the warm water to melt all the ice so you end w/ a combo of ice & water

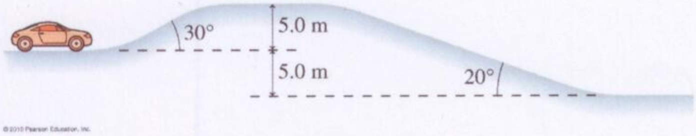
19. Recall the in class demonstration where the pop can had a little bit of boiling water inside and was dipped upside down in cold water. Why was the can crushed?
    - a. The warm air molecules inside quickly rushed out when they came in contact with the cold water.
    - b. The hot and cold molecules react when they come in contact.
    - [✓ c.] The steam inside the can quickly condensed to water when it came in contact with the cold water causing the outside air molecules to crush the can.

20. Describe the behavior of a substance that has a temperature of -20K?

It's not possible since molecules stop moving at 0 K.

For the following problems, ***show all work for credit.***

21. A container holds 5 kg of steam at 150°C which is put in thermal contact with 1 kg of water at 0°C. What is the final temperature of the system? What is the final mass of steam? What is the final mass of water? c_{water} = 4186 J/kg°C, c_{ice} = 2090 J/kg°C, c_{steam} = 2010 J/kg°C, L_f = 3.33 x 10^5 J/Kg, L_v = 2.26 x 10^6 J/kg



22. The car in the figure to the right has a mass of 1200 kg. The car suddenly runs out of gas while traveling at 12 m/s, rolls over the hill and is traveling at 12 m/s at the bottom of the hill on the far right. He travels 40 meters during this time.
    - a. How much energy was converted to thermal energy?
    - b. How much work is done by friction?
    - c. What is the force of friction?

21. 5kg steam @ 150°C
1kg water @ 0°C

steam to 100 $mc\Delta T = 5\text{kg}\ 2010\,\text{J/kgK}\ (100-150) = -502{,}500\text{J}$

water to 100 $mc\Delta T = 1\text{kg}\ 4186\,\frac{\text{J}}{\text{kgK}}\ (100-0) = 418{,}600\text{J}$

This means we'll have some of the water turn to steam since the energy released from 150°C steam cooling to 100°C is more than it takes to heat cold water to 100°C. Now extra energy goes into vaporizing some of the water.

$$Q_{lost} + Q_{gained} = 0$$

$$Q_{150\to100} + Q_{0\to100} + Q_{vap} = 0$$

$$-502{,}500\text{J} + 418{,}600\text{J} + mL_v = 0$$

$$-83{,}900\text{J} + m\,2.26\times10^{6}\,\text{J/kg} = 0$$

$$m = 0.037\text{ kg}$$

So $\boxed{T_F = 100°C}$ (steam & water at equilibrium at atm pressure

$$m_{steam} = 5\text{kg} + 0.037\text{kg} = \boxed{5.037\text{kg}}$$

$$m_{water} = 1\text{kg} - 0.037\text{kg} = \boxed{0.963\text{kg}}$$

22. a. $K_i + U_{gi} = K_f + \overset{=0}{\cancel{U_{gf}}} + E_{TH}$

I'm going to say h=0 at the bottom of the hill which means I started at 5m.

$$\tfrac{1}{2}mv_i^2 + mgh_i = \tfrac{1}{2}mv_f^2 + E_{TH}$$

$$\cancel{\tfrac{1}{2}mv_i^2} - \tfrac{1}{2}mv_f^2 + mgh = E_{TH}$$

$$1200\text{kg}\ 9.8\ 5\text{m} = \boxed{58{,}800\text{J}}$$

b. $W = \Delta E = \boxed{-58{,}800\text{J}}$

negative because friction is in the opposite direction of the displacement

c. $W = F \cdot \Delta x$

$$\frac{W}{\Delta x} = F = \frac{-58{,}800\text{J}}{40\text{m}} = \boxed{-1470\text{N}}$$