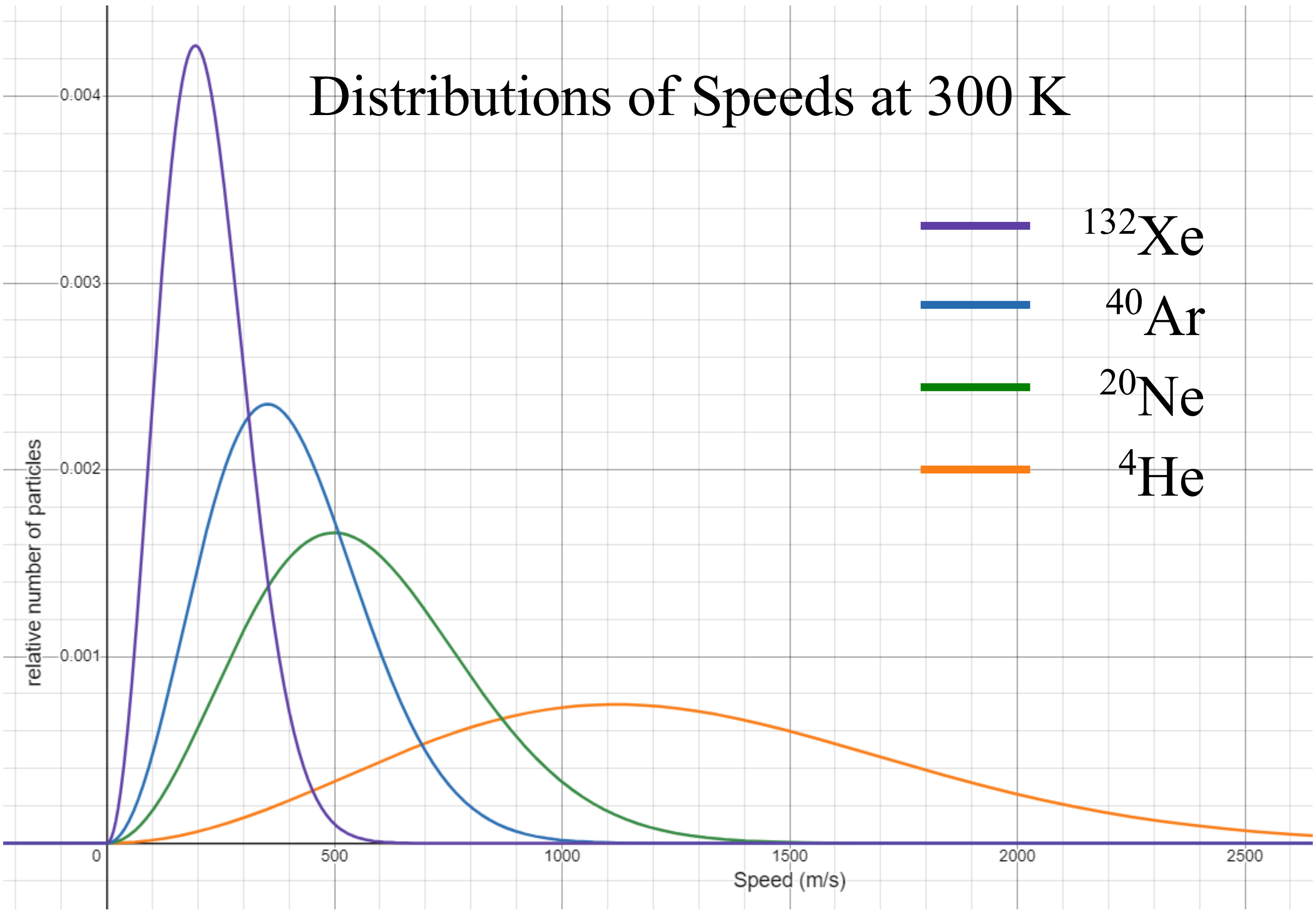
1. (a) Use the ideal gas constant and law to determine the volume of one mole of gas at standard temperature and pressure (273 K and 1 atm). (b) Determine the volume if the temperature is 30<u>0</u> K and pressure is still 1 atm. (c) Determine the volume if the pressure is 1.5 atm and the temperature is still 273 K.

2. (a) Why does warm air rise? (b) If warm air rises why is it cold atop a mountain?

3. A certain balloon at 23 °C holds 10.0 grams of air (29.0 g/mol) at gauge pressure 17 cm-H_2O. (a) Use Boltzmann's constant to determine the volume of the balloon. (b) By how many millimeters (radius) is the air inside "squeezed" by the rubber of the balloon? (c) Use the same pressure, temperature, and volume and determine the number of molecules and mass if the balloon holds helium.

4. Use the assumptions of the kinetic theory to derive an expression for the pressure on one end of a rectangular volume in terms of the average kinetic energy of the molecules of an ideal gas.

5. Use the Boltzmann constant to determine the average speed and kinetic energy for a molecule of each type of gas shown at a temperature of 30<u>0</u> K. Calculate the most likely kinetic energy of a single atom of each type of gas based on the curves shown. Why the discrepancy?



Note: interactive version of graph can be found at https://www.desmos.com/calculator/jpigtbhm7g

6. Determine the average speed of oxygen and nitrogen molecules at room temperature 20.0 °C. The *total* internal energy of diatomic gases is often modeled by $U = 5/2\ kT$. How much "extra" energy does a nitrogen molecule have beyond its translational kinetic energy?

7. How many collisions per second occur between atmospheric molecules and your fingernail? Estimate using an area of one square centimeter.

8. Reentry of a spacecraft with the atmosphere can generate great heat. Suppose the speed of the craft relative to the atmosphere is 7900 m/s. Determine the temperature at which nitrogen has this speed on average.

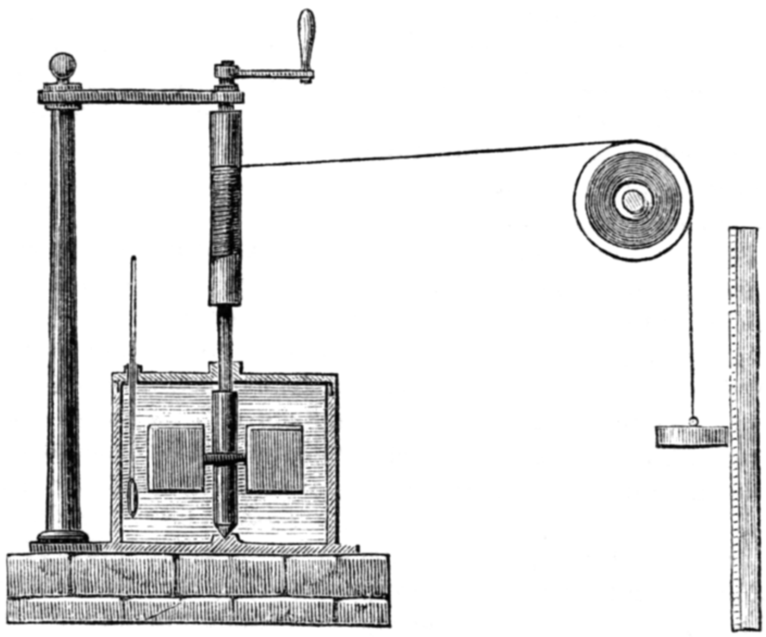
9. A pane of glass in a certain window has dimensions 0.50 m by 1.50 m has a thickness 1.8 mm. The air in contact with the glass on one side is at 16 °C while the air on the other side is 14.5 °C. (a) Determine the rate of heat loss through the window due to thermal conductivity. (b) Suppose the home owner turns up the heat and the inside temperature increases by 1 °C – find the increase in heat loss.

10. A pot on the stove with diameter 16 cm holds some water initially at 20.0 °C. The temperature of the stove's eye is 175 °C. Determine the rate at which the heat passes through the 2.00 mm thick bottom of the pan if it is: (a) copper, or (b) aluminum.
(c) Determine the rate once the water is boiling?!
(d) Given that the stove eye is 220 V and carries current 11 A, estimate the temperature of the part of the eye touching the pot's bottom while boiling.

11. The insulation *R*-value of a building material is measured in units of $ft^2 \cdot h \cdot F°/Btu$. (a) Determine the *R* value of glass of thickness 1/8 inch. (b) If the *R* value of 4 inches of fiberglass insulation is 12, what is the thermal conductivity of the material?

12. Suppose a steel rod ($k = 45$ J/s·m·C°) is connected at one end to a second rod of the same diameter and length made of aluminum ($k = 240$ J/s·m·C°). The free end of one rod is held at 100.0 °C in boiling water and the free end of the other is held at 0.0 °C in ice water. (a) Determine the temperature at the point where the rods are connected. (b) Determine the rate of heat flow if each rod is 0.40 m long and radius 0.0050 m. (c) Find the effective thermal conductivity for the combined rods.

13. A block of mass 5.0 kg is pulled downward 3.0 m. Determine the change in the internal energy of the system. Joule's experiment relating work to heat:



14. A certain ice cream freezer requires 1250 turns of the handle with torque of 2.00 Nm to keep the dasher turning as 1.20 kg of milk/cream mixture freezes. The heat of fusion for the mixture is 285 J/g. (a) Determine the heat for the ice cream as it forms. (b) Determine the heat for the brine surrounding the tub as the ice cream forms.

15. A closed rigid container contains a 1.0 L volume of ideal monatomic gas. Initially it is at pressure 1.0 atm and temperature 20.0 °C. (a) Find the heat if it is moved to a location at 0.0 °C. (b) Find the heat for a second change – this time moved to a location at 30.0 °C.

16. Consider what happens to a helium balloon of initial volume 6.00 L if the temperature increases from 0.0 °C to 22.0 °C. Suppose the pressure remains constant at 1.02 atm. (a) Determine the change in volume. (b) Find the work done on the helium gas. (c) Determine the heat. (d) Repeat for air filled.

17. A vertical cylinder with radius 5.00 cm contains an 0.0165 moles of ideal monatomic gas initially at 298 K. A movable piston "on top" of the gas has a mass of 2.00 kg. (a) Determine work and heat if temperature is raised to 398 K. (b) Show that the work done by the force of the gas on the piston equals that found by pressure times volume change.

18. The gas/cylinder in the previous problem undergoes an isochoric cooling and an isothermal contraction to return to its original state. Determine the heat and work for each part of the cycle and the efficiency of the engine.