

■ **Hwk 1**
—24 Jan 2011

■ **Problem 1**

In class we found that the temperature and speed are related by

$$\frac{1}{2} k T = \frac{3}{2} m v^2,$$

where m is the mass of one atom and v is the speed of the meteor as it hits earth. Notice v is independent of the mass and composition of the meteor, because of what Galileo found out: A lead cannonball falls at the same speed as a wooden ball.

a) The speed of a calcium meteor is also 11km/s.

b) This equation says the temperature is proportional to the mass of the atoms in the meteor. The temperature of the calcium meteor is

$$290\,000. \text{ Kelvin } (40 / 56)$$

$$207\,143. \text{ Kelvin}$$

c) The composition changes the temperature somewhat for rocky meteors. However, if the meteor were made of water (it would be a comet), the temperature is a lot lower. In that case, the average mass of water is

$$(2 + 16) / 3.$$

$$6.$$

The temperature is

$$290\,000. \text{ Kelvin } (6 / 56)$$

$$31\,071.4 \text{ Kelvin}$$

■ **Problem 2**

a) The potential energy of the blob of iron changes when it sinks from the surface to the center of earth. The kinetic energy

$$\text{KE}(\text{center}) + \text{PE}(\text{center}) = \text{KE}(\text{surface}) + \text{PE}(\text{surface})$$

$$\frac{1}{2} m v^2 = \frac{4\pi}{3} G m \rho R^2$$

where v is the speed at the center and R is the radius of earth. Alternatively, $\frac{4\pi}{3} \rho R^3 = M$, and

$$\frac{1}{2} v^2 = G M / R$$

<< PhysicalConstants ^

$$v_{\text{SinkInEarth}} = \text{Sqrt}[2 \text{ GravitationalConstant EarthMass} / \text{EarthRadius}]$$

$$11\,181.8 \sqrt{\frac{\text{Meter Newton}}{\text{Kilogram}}}$$

$$\text{Convert}[v_{\text{SinkInEarth}}, \text{Kilo Meter} / \text{Second}]$$

$$\frac{11.1818 \text{ Kilo Meter}}{\text{Second}}$$

```
temperatureBlob[velocity_, mass_: 1] :=  
  Convert[0.5 mass ProtonMass velocity2 / (1.5 BoltzmannConstant), Kelvin]  
  
temperatureBlob[vSinkInEarth, 57]  
  
Convert::temp : Warning: Convert[old,new] converts units of  
  temperature. ConvertTemperature[temp,old,new] converts absolute temperature. >>  
  
287 798. Kelvin
```

(b) The sinking blob moves very fast at the center of earth, and its energy becomes converted to a temperature (290kK) that is high enough to melt rock. Therefore, differentiation (sinking of heavy stuff) heats the material to a temperature hot enough to melt rock.