Pop Quiz 3, Chemistry 481, 18 Sep 2019. Name: _____

1. An equation of state expresses the pressure as a function of the independent variables T and $\bar{V} = V/n$. The van der Waal's n of state is

$$P = \frac{RT}{\bar{V} - b} - \frac{a}{\bar{V}^2} \tag{1}$$

We could replace the molar volume by the molar density $\rho = 1/\bar{V}$, where ρ has units mol/m^3. Write the van der waals equation of state in terms of T and ρ. (3 pts) Substituting $\bar{V} = 1/\rho$ into Eq. (1), we find

$$P = \frac{RT}{1/\rho - b} - a\rho^2$$

You can also simplify the first term to get

$$P = \frac{\rho RT}{1 - b\rho} - a\rho^2$$

2. The Maxwell-Boltzmann distribution of speeds s of the atoms (or molecules) in a gas is

$$f(s) = Cs^2 \exp(-ms^2/2k_BT)$$

where m is the mass of the gas and

$$C = \sqrt{\left(\frac{m}{k_BT}\right)^3 \frac{2}{\pi}}$$

a. Sketch $f(s)$ as a function of s. (3 pts)

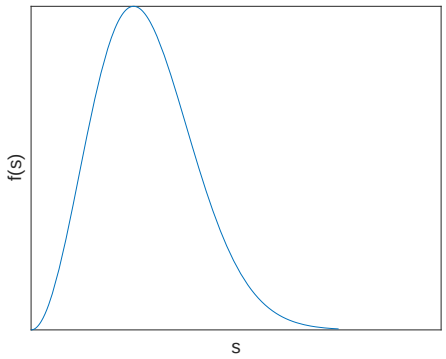

FIG. 1: Note that axes should be labelled for full credit

b. An estimate of the average speed is the root-mean-squared value of the speed, $\langle s^2 \rangle^{1/2}$. Determine this in terms of m and T. *Hint: this is mathematically very simple.* (4 pts) The average energy of a gas is $\langle E \rangle = \frac{3}{2} k_B T$. This energy is kinetic energy, so $\langle E \rangle = \frac{1}{2} m \langle s^2 \rangle$. Equating the two, gives $\langle s^2 \rangle = 3 k_B T / m$, so that $\langle s^2 \rangle^{1/2} = \sqrt{3 k_B T / m}$. We did this in class on 13 Sept.