244hw1

HOMEWORK 1 SOLUTIONS

3-3 The electron kinetic energy is

$$5\times10^{4}\,eV = (5\times10^{4}\,eV)\cdot(1.602\times10^{-19}\,J/eV)$$
$$= 8.01\times10^{-15}\,J$$

Using $E = \frac{1}{2}mv^2$ we get

$$v = \left[\frac{2E}{m}\right]^{\frac{1}{2}} = \left[\frac{2(8.01\times10^{-15}J)}{9.11\times10^{-31}kg}\right]^{\frac{1}{2}} = 1.326\times10^{8}\,m/s$$

Now if the forces balance then

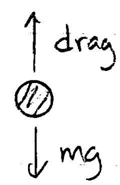
$$q\mathcal{E} = qvB$$

so we need

$$B = \mathcal{E}/v = (2\times10^{5}V/m)/(1.326\times10^{8}m/s)$$
$$= 1.51\times10^{-3}\,\text{Tesla} \Rightarrow \boxed{B = 15.1G}$$

NOTE: The velocity we found above is around half the speed of light, so technically we should be using relativistic formulas to find v (I don't expect you to know this since we didn't cover relativity). The correct velocity is $1.238\times10^{8}\,m/s$.

3-11 (a) The drop is falling at constant velocity, so the net force is zero. For $\mathcal{E}=0$ the force is



$$F = mg - bv \Rightarrow \text{we have} \quad mg = bv$$

Here

$$m = \rho\cdot V = \rho\cdot\frac{4\pi}{3}a^3 \quad \text{and} \quad b = 6\pi\eta a$$

so

$$\frac{4\pi}{3}\rho a^3\cdot g = 6\pi\eta a\cdot v_t \qquad \rho = 0.75\,g/cm^3 = 750\,kg/m^3$$

$\Rightarrow$

$$a^2 = 6\pi\eta v_t\left(\frac{3}{4\pi}\right)/\rho\cdot g = \frac{6\left(1.8\times10^{-5}\frac{N\cdot s}{m^2}\right)\left(\frac{5\times10^{-3}m}{20s}\right)\left(\frac{3}{4}\right)}{(9.8m/s^2)(750\,kg/m^3)}$$

$$\boxed{a = 1.66\times10^{-6}m = 1.66\mu m}$$

And for the mass

$$m = (750\ \mathrm{kg/m^3})\left(\frac{4\pi}{3}\right)(1.66\times10^{-6}\ \mathrm{m})^3 \Rightarrow \boxed{m = 1.437\times10^{-14}\ \mathrm{kg}}$$

(b) The ratio is

$$\frac{F_e}{F_g} = \frac{q\mathcal{E}}{mg} = \frac{(2)(1.602\times10^{-19}\ \mathrm{C})(2.5\times10^{5}\ \mathrm{V/m})}{(1.437\times10^{-14}\ \mathrm{kg})(9.8\ \mathrm{m/s^2})} = \boxed{0.57}$$

8-3 We know that $\langle \frac{1}{2}mv^2\rangle = \frac{3}{2}kT \Rightarrow \langle v^2\rangle = 3kT/m$ where m is the mass of each molecule. Multiplying above and below by N_A and using $R = kN_A$ we get

$$\langle v^2\rangle = 3RT/mN_A$$

where mN_A is now the mass of 1 mole. We want $v_{RMS} = \sqrt{\langle v^2\rangle}$

(a) For oxygen mN_A is 32 grams = 0.032 kg

$$v_{RMS} = \left[\frac{(3)(8.314\ \mathrm{J/K})(273\ \mathrm{K})}{0.032\ \mathrm{kg}}\right]^{\frac{1}{2}} = \boxed{461\ \mathrm{m/s}}$$

(b) For hydrogen $mN_A = 2g$ and we get $\boxed{v_{RMS} = 1845\ \mathrm{m/s}}$

8-10 The total translational KE is the number of molecules times the average KE, $U = N\langle E\rangle = N\cdot\frac{3}{2}kT$. But $N = nN_A$ where n is the number of moles of gas, so

$$U = nN_A(3/2)kT = \frac{3}{2}n(kN_A)T = \frac{3}{2}nRT$$

But from the ideal gas law $nRT = PV$

so

$$U = \frac{3}{2}PV = \frac{3}{2}(1\ \mathrm{Atm})(1\ \ell) = \frac{3}{2}(1.01\times10^5\ \mathrm{N/m^2})(10^{-3}\ \mathrm{m^3})$$

$$\boxed{U = 151.5\ \mathrm{J}}$$

E-1 (a) The density of liquid helium is .125g/cm^3. The atomic weight is 4.0026 g/mole so we have

$$n/V = (0.125 g/cm^3)/(4.0026 g/mole) = 3.12 \times 10^{-2} \text{ moles/cm}^3$$
$$N/V = (3.12 \times 10^{-2} \text{ moles/cm}^3) \cdot (6.02 \times 10^{23} \text{ atoms/mole})$$
$$\boxed{N/V = 1.88 \times 10^{22} \text{ atoms/cm}^3}$$

(b) Here we use the ideal gas law, $PV = nRT \Rightarrow \frac{n}{V} = \frac{P}{RT}$
$\Rightarrow$

$$\frac{N}{V} = N_A \cdot \frac{n}{V} = N_A \cdot \frac{P}{RT} = (6.02 \times 10^{23}) \frac{(1.01 \times 10^5 N/m^2)}{(8.314 J/K)(5K)}$$

$$\frac{N}{V} = 1.46 \times 10^{27}/m^3 = \boxed{1.46 \times 10^{21} \text{ atoms/cm}^3}$$

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