GPN1-L13

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Problem 1

Answer the following questions: (05小題)

(a)Gold has a molar mass of 197 g/mol. (a1) How many moles(n) of gold are in a 2.50 g sample of pure gold? (a2) How many atoms(N) are in the sample?

(a1)n=______

$$n = M_{\rm sam}/M = 2.5/197 = 0.0127 \text{ mol.}$$

01: **ANS:=0.0127**

(a2)N=_____

$$N = nN_A = (0.0127)(6.02 \times 10^{23}) = 7.64 \times 10^{21}.$$

02: **ANS:=7.64E21**

(b)Find the mass(m) in kilograms of 7.50×10^{24} atoms of arsenic, which has a molar mass of 74.9 g/mol. m=______ kg

03: **ANS:=0.933**

$$(7.50 \times 10^{24})(74.9 \times 10^{-3} \text{ kg/mol})/(6.02 \times 10^{23} \text{ mol}^{-1}) = 0.933 \text{ kg.}$$

(c)The best laboratory vacuum has a pressure of about 1.00×10^{-18} atm, or 1.01×10^{-13} Pa. How many gas molecules are there per cubic centimeter in such a vacuum at 293 K? N=______

04: **ANS:=25**

(d)Compute (a) the number of moles(n) of molecules in 1.00 cm^3 of an ideal gas at a pressure of 100 Pa and a temperature of 220 K. n=______

05: **ANS:=5.47E-8**

$$n = \frac{pV}{RT} = \frac{(100\,\text{Pa})(1.0\times10^{-6}\text{m}^3)}{(8.31\,\text{J/mol}\cdot\text{K})(220\,\text{K})} = 5.47 \times 10^{-8}\text{mol.}$$

$V = 1.0 \times 10^{-6}$ m^3, $p = 1.01 \times 10^{-13}$ Pa, and $T = 293$ K,

$$n = \frac{pV}{RT} = \frac{(1.01\times10^{-13}\text{ Pa})(1.0\times10^{-6}\text{ m}^3)}{(8.31\text{ J/mol}\cdot\text{K})(293\text{ K})} = 4.1\times10^{-23}\text{ mole.}$$

$$N = nN_A = 25 \text{ molecules.}$$

Problem 2

A quantity of ideal gas at 10.0°C and 100 kPa occupies a volume of 2.50 m^3. (a) How many moles, n, of the gas are present? (b) If the pressure is now raised to 300 kPa and the temperature is raised to 30.0°C, how much volume V does the gas occupy? Assume no leaks. (02小題)

(a)n=____

06: **ANS:=106**

$$n = \frac{pV}{RT} = \frac{(100 \times 10^3 \text{ Pa})(2.50 \text{ m}^3)}{(8.31 \text{ J/mol}\cdot\text{K})(283 \text{ K})} = 106 \text{ mol.}$$

(b)V=_____ m^3

07: **ANS:=0.892**

$$\frac{p_f V_f}{p_i V_i} = \frac{T_f}{T_i} \quad V_f = V_i \left(\frac{p_i}{p_f}\right)\left(\frac{T_f}{T_i}\right) = (2.50 \text{ m}^3)\left(\frac{100 \text{ kPa}}{300 \text{ kPa}}\right)\left(\frac{303 \text{ K}}{283 \text{ K}}\right) = 0.892 \text{ m}^3$$

Problem 2

Suppose 1.80 mol of an ideal gas is taken from a volume of 3.00 m^3 to a volume of 1.50 m^3 via an isothermal compression at 30°C. (a) How much energy is transferred as heat during the compression, and (b) is the transfer to or from the gas? (02小題)

(a)the magnitude of energy transferred as heat=______ J

08: **ANS:=3.14E3**

(b)1=the heat transfer to the gas; 2=the heat transfer from the gas. Ans.=____

09: **ANS:=2**

$$Q = W.$$

$$W = nRT \ln \frac{V_f}{V_i} \qquad T = (273 + 30.0)\text{K}$$

$$Q = -3.14 \times 10^3 \text{ J, or } |Q| = 3.14 \times 10^3 \text{ J.}$$

That negative sign in the result of part (a) implies the transfer of heat is *from* the gas.

Problem 3

An air bubble of volume 20 cm3 is at the bottom of a lake 40 m deep, where the temperature is 4.0°C.The bubble rises to the surface, which is at a temperature of 20°C.Take the temperature of the bubble's air to be the same as that of the surrounding water. Just as the bubble reaches the surface, what is its volume? (01小題)

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its volume at the surface, V_2=_____ cm^3

10: **ANS:=<u>100</u>**

We assume that the pressure of the air in the bubble is essentially the same as the pressure in the surrounding water. If d is the depth of the lake and ρ is the density of water, then the pressure at the bottom of the lake is $p_1 = p_0 + \rho g d$, where p_0 is atmospheric pressure. Since $p_1V_1 = nRT_1$, the number of moles of gas in the bubble is

$$n = p_1V_1/RT_1 = (p_0 + \rho g d)V_1/RT_1,$$

where V_1 is the volume of the bubble at the bottom of the lake and T_1 is the temperature there. At the surface of the lake the pressure is p_0 and the volume of the bubble is $V_2 = nRT_2/p_0$. We substitute for n to obtain

$$V_2 = \frac{T_2}{T_1}\frac{p_0 + \rho g d}{p_0}V_1$$

$$= \left(\frac{293\,\text{K}}{277\,\text{K}}\right)\left(\frac{1.013\times10^5\ \text{Pa} + \left(0.998\times10^3\ \text{kg/m}^3\right)\left(9.8\,\text{m/s}^2\right)\left(40\,\text{m}\right)}{1.013\times10^5\ \text{Pa}}\right)\left(20\,\text{cm}^3\right)$$

$$= 1.0\times10^2\ \text{cm}^3.$$

Problem 4

Answer the following questions: (04小題)

(a)The lowest possible temperature in outer space is 2.7 K. The rms speed of hydrogen molecules at this temperature, V_{rms} =_______ m/s

11: **ANS:=180**

$$v_{rms} = \sqrt{\frac{3(8.31\,\text{J/mol}\cdot\text{K})(2.7\,\text{K})}{2.02\times10^{-3}\,\text{kg/mol}}} = 1.8\times10^{2}\ \text{m/s}.$$

(b) The temperature and pressure in the Sun's atmosphere are 2.00×10^{6} K and 0.0300 Pa. Calculate the rms speed of free electrons (mass 9.11×10^{-31} kg) there, assuming they are an ideal gas. V_{rms}=______ m/s

12: **ANS:=9.53E6**

$k = 1.38\times10^{-23}$ J/K $T = 2.00\times10^{6}$ K, $v_{rms} = 9.53\times10^{6}$ m/s.

$$v_{rms} = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3(kN_A)T}{(mN_A)}} = \sqrt{\frac{3kT}{M}}.$$

(c)A beam of hydrogen molecules (H^2) is directed toward a wall, at an angle of 55° with the normal to the wall. Each molecule in the beam has a speed of 1000 m/s and a mass of 3.3×10^{-24} g. The beam strikes the wall over an area of 2.0 cm^2, at the rate of 10^{23} molecules per second. What is the beam's pressure on the wall? P=______ Pa

13: **ANS:=1.9E3**

(d)What is the average translational kinetic energy of nitrogen molecules at 1600 K? K=____ J

14: **ANS:=3.31E-20**

$$p = \frac{2}{A}\left(\frac{N}{\Delta t}\right) mv\cos\theta$$
$$= \left(\frac{2}{2.0\times10^{-4}\,\text{m}^2}\right)(1.0\times10^{23}\,\text{s}^{-1})(3.3\times10^{-27}\,\text{kg})(1.0\times10^{3}\,\text{m/s})\cos55^\circ$$
$$= 1.9\times10^{3}\ \text{Pa}.$$

$$K_{avg} = \tfrac{3}{2}kT \qquad k = 1.38\times10^{-23}\ \text{J/K}$$

$$K_{avg} = \frac{3}{2}(1.38\times10^{-23}\,\text{J/K})(1600\,\text{K}) = 3.31\times10^{-20}\ \text{J}$$

Problem 5

Ten particles are moving with the following speeds: four at 200 m/s, two at 500 m/s, and four at 600 m/s. Calculate their (a) average and (b) rms speeds. (02小題)

(a) average speed=______ m/s

15: **ANS:=420**

$$v_{avg} = \frac{1}{N}\sum_{i=1}^{N} v_i = \frac{1}{10}[4(200 \text{ m/s}) + 2(500 \text{ m/s}) + 4(600 \text{ m/s})] = 420 \text{ m/s}.$$

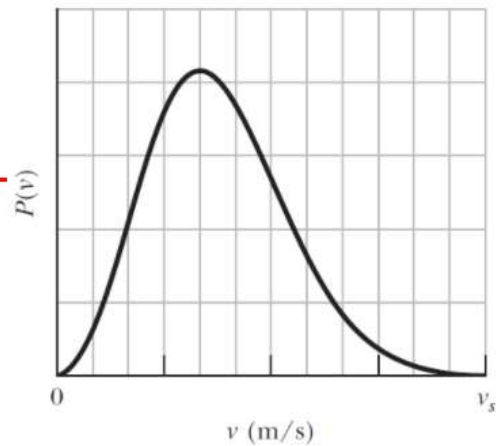
(b) rms speed=______ m/s

16: **ANS:=458**

$$v_{rms} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} v_i^2} = \sqrt{\frac{1}{10}[4(200 \text{ m/s})^2 + 2(500 \text{ m/s})^2 + 4(600 \text{ m/s})^2]} = 458 \text{ m/s}$$

Problem 5

The figure gives the probability distribution for nitrogen gas. The scale of the horizontal axis is set by vs = 1200 m/s. What are the (a) gas temperature and (b) rms speed of the molecules? (02小題)



(a)the gas temperature, T=______ K

17: **ANS:=270**

(b) rms speed of the molecules=_______ m/s

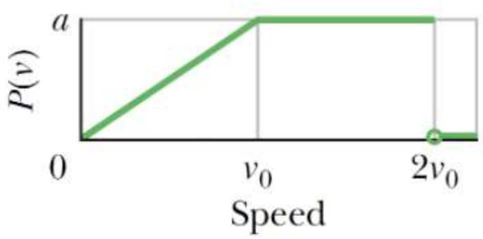
18: **ANS:=490**

$$v_p = 400 \text{ m/s}. \quad M = 28 \text{ g/mol}$$

$$T = \tfrac{1}{2}Mv_p^2/R = 2.7\times10^2 \text{ K}. \qquad v_{rms} = \sqrt{3/2}\, v_p = 4.9\times10^2 \text{ m/s}.$$

Problem 6

The figure shows a hypothetical speed distribution for a sample of N gas particles (note that $P(v) = 0$ for speed $v > 2v_0$). What are the values of (a) $a_v 0$, (b) v_{avg}/v_0, and (c) v_{rms}/v_0? (d) What fraction of the particles has a speed between $1.5v_0$ and $2.0v_0$? (04小題)



(a) $a_v 0$=____

19: **ANS:=2/3**

(b) v_{avg}/v_0=______

20: **ANS:=1.22**

(c) v_{rms}/v_0=______

21: **ANS:=1.31**

(d) the fraction between $1.5v_0$ and $2.0v_0$=____

22: **ANS:=1/3**

$$\int P(v)dv = \frac{1}{2}av_0 + av_0 = \frac{3}{2}av_0\,,$$

so $\frac{3}{2}av_0 = 1$ and $av_0 = 2/3 = 0.67$.

$$v_{\text{avg}} = \int vP(v)\,dv.$$

$$\frac{a}{v_0}\int_0^{v_0} v^2 dv = \frac{a}{3v_0}v_0^3 = \frac{av_0^2}{3} = \frac{2}{9}v_0,$$

$P(v) = a$ in the rectangular portion,

$$a\int_{v_0}^{2v_0} v\,dv = \frac{a}{2}\left(4v_0^2 - v_0^2\right) = \frac{3a}{2}v_0^2 = v_0.$$

$$v_{\text{avg}} = \frac{2}{9}v_0 + v_0 = 1.22v_0 \quad \Rightarrow \quad \frac{v_{\text{avg}}}{v_0} = 1.22\,.$$

$$v_{\text{rms}}^2 = \int v^2 P(v)\,dv.$$

$$\frac{a}{v_0}\int_0^{v_0} v^3 dv = \frac{a}{4v_0}v_0^4 = \frac{1}{6}v_0^2.$$

$$a\int_{v_0}^{2v_0} v^2 dv = \frac{a}{3}\left(8v_0^3 - v_0^3\right) = \frac{7a}{3}v_0^3 = \frac{14}{9}v_0^2.$$

$$v_{\text{rms}} = \sqrt{\frac{1}{6}v_0^2 + \frac{14}{9}v_0^2} = 1.31v_0 \quad \frac{v_{\text{rms}}}{v_0} = 1.31\,.$$

$$N\int_{1.5v_0}^{2v_0} P(v)dv = Na(2.0v_0 - 1.5v_0)$$

$$= 0.5N\,av_0 = N/3,$$

the fraction of particles $= 1/3$