Chemistry 135 Semester 01-2012
Homework for Submission #3

Answer the following questions in the spaces provided on this paper and submit them for marking on or before 4 pm on Monday 6th February in the chemistry drop box. If any answers show evidence of copying, the whole exercise will attract zero marks.

Clear and concise working, starting with a statement of the principle or equation employed, must be shown if full marks are to be earned. Answers must be shown with units (where appropriate) and to the correct number of significant figures.

Develop your answers carefully in rough before placing them on the sheet for submission.

1) Convert 23.5 atm to (3)

a) Pascals, Pa.

1 atm = 101325 Pa

∴ 23.5 atm = 23.5 × 101325 Pa = $2.3811... \times 10^6$ Pa

= 2.38×10^6 Pa for 3 s.f.

b) millimetres of mercury, mmHg. (3)

1 atm = 760 mmHg

∴ 23.5 atm = 23.5 × 760 mmHg = 1.786×10^4 mmHg

= 1.79×10^4 mmHg for 3 s.f.

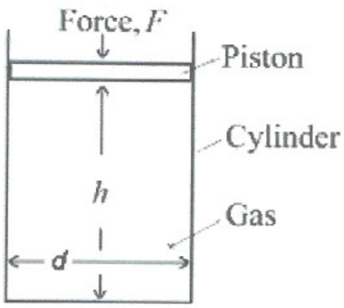
2) Convert 1.00 Pa to mmHg (3)

101325 Pa = 760 mmHg

∴ 1.00 Pa = $\frac{760}{101325}$ mmHg = $7.5006... \times 10^{-3}$ mmHg

= 7.50×10^{-3} mmHg to 3 s.f.

3) A gas is enclosed in a cylinder with a circular (weightless and frictionless) piston which makes a perfect seal. If the cylinder has an internal diameter, *d*, of 25 cm, and a force of 2.00×10^3 N is acting down on the piston, calculate the pressure of the gas inside the cylinder in Pascals, given that the upward force due to the pressure just balances the downward force exerted by the piston. (4)



Area of piston = $\pi r^2 = \frac{\pi d^2}{4}$

= $\frac{\pi \times 25^2}{4}$ = $4.9087... \times 10^2$ cm²

But 1 cm² = 10^{-4} m²

∴ Area = $4.9087... \times 10^2 \times 10^{-4}$ m²

= $4.9087... \times 10^{-2}$ m²

∴ Downward pressure = $\frac{\text{Force}}{\text{Area}}$

= $\frac{2.00 \times 10^3 \text{ N}}{4.9087... \times 10^{-2} \text{ m}^2}$ = $4.07439... \times 10^4$ N m^{-2}

But 1 N m^{-2} = 1 Pa

∴ Pressure of gas = Downward pressure = 4.07×10^4 Pa to 3 s.f.

4) Weather balloons are big limp bags whose volume can vary over a wide range without any stretching of the fabric. A balloon is filled with 351 L of hydrogen gas at sea level where the pressure is 957 torr. The balloon then rises to an altitude of several miles where the pressure is only 198 mbar.

a) Assuming that the temperature is the same as at sea level, calculate the volume of the hydrogen in the balloon after the ascent of the balloon. (3)

Volume & pressure change, but temp. & mass of gas remain constant. We apply Boyle's law:

$P_1 V_1 = P_2 V_2$

$\therefore V_2 = V_1 \frac{P_1}{P_2} = 351L \times \frac{957 \text{ torr} \; (1.33322)}{198 \text{ mbar}} = 2.2618... \times 10^3 L = \underline{\underline{2.26 \times 10^3 L}}$ to 3 s.f.

b) If the temperature at sea level is 25°C, and that at the altitude of the balloon is -25°C, calculate the volume of hydrogen, either from your answer to part (a), or otherwise. (3)

From part (a) only temp. and volume change. Hence we apply Charles's law:

unrounded value, still in calculator

$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \therefore V_2 = V_1 \times \frac{T_2}{T_1} = 2.26180... \times 10^3 L \times \frac{(273-25)K}{(273+25)K}$

$= 1.88230... \times 10^3 L = \underline{\underline{1.88 \times 10^3 L}}$ to 3 s.f.

convert to Kelvin!

5) 0.000351 mol of hydrogen is collected in a gas syringe. The volume is measured as 8.40 cm^3. 0.000425 mol of nitrogen is then collected under the same conditions of temperature and pressure. What is the volume of the nitrogen? (3)

Since $PV = nRT$ (ideal gas law), $\frac{n}{V} = \frac{P}{RT}$. But P, R and T are constant, hence $\frac{n}{V}$ = const. and $\frac{n_1}{V_1} = \frac{n_2}{V_2}$

$\therefore V_2 = \frac{n_2}{n_1} V_1 = \frac{0.000425 \text{ mol}}{0.000351 \text{ mol}} \times 8.40 cm^3 = 10.1709... cm^3$

$= \underline{\underline{10.2 cm^3}}$ to 3 s.f.

6) Calculate the number of moles present in a sample of gas whose volume is 22.4 dm^3 at a pressure of 10000 Pa and a temperature of 24°C. (6)

Since $PV = nRT$ (ideal gas equation)

$\therefore n = \frac{PV}{RT} = \frac{10000 Pa \times 22.4 dm^3}{8.31 J mol^{-1} K^{-1} \times (273+24) K}$

But $1 Pa = 1 N m^{-2}$ and $1 J = 1 N.m$

$\therefore n = \frac{10000 N m^{-2} \times 22.4 dm^3}{8.31 N.m.mol^{-1} K^{-1} \times 297 K} = \frac{10000 \times 22.4}{8.31 \times 297} \frac{dm^3}{m^3}$ mol

(corrections: 10000 → 10; $\frac{dm^3}{m^3} = \frac{1}{1000}$) since $1000 dm^3 = 1 m^3$

$\therefore n = 9.07591... \times 10^{-2}$ mol

$= \underline{\underline{9.08 \times 10^{-2} \text{ mol}}}$ to 3 s.f.

* from www.unitconversion.org : 1 torr = 1.333223684 mbar

1 torr ≠ 1 mbar (millibar) — sorry for misinforming some students