Name ________________ Section No. __________ Marks 29/10

TEST ON THE GAS LAWS AND RELATED MATTERS

You may need some of the following information: $R = 8.31\,J\,mol^{-1}K^{-1} = 0.0821\,L\,atm\,mol^{-1}K^{-1}$. The molar volume of any gas at s.t.p. is $22.4\,L\,mol^{-1}$. Underline numerical answers and express them to the correct number of significant figures or decimal places. Note that answers without working cannot be awarded marks, but that incorrect answers may attract marks if working is shown.

1) A sample of gas was heated from 17°C to 523°C in a sealed container of constant volume. The initial pressure of the gas was 1.02 atm. Calculate the final pressure in the container. (3)

Ideal gas law $PV = nRT$. If P & T vary and n, V are constant: $\frac{P}{T} = \frac{nR}{V}$ = const.

$\therefore \frac{P_1}{T_1} = \frac{P_2}{T_2}$

$\therefore P_2 = \frac{T_2}{T_1} \times P_1 = \frac{(523+273)}{(17+273)} \times 1.02\,atm = 2.79972... = \underline{2.80\,atm}$ to 3 s.f.

2) $249\,cm^3$ of a certain gas are collected in a gas syringe at pressure of 100 kPa and a temperature of 27°C.

a) Calculate the number of moles of the gas. (3)

$PV = nRT$

$\therefore n = \frac{PV}{RT} = \frac{100\,kPa \times 249\,cm^3}{8.31\,J\,mol^{-1}K^{-1} \times (27+273)K} = \frac{100000\,Pa \times 249 \times 10^{-6}\,m^3}{8.31\,J\,mol^{-1}K^{-1} \times 300\,K}$

$= 9.987966... \times 10^{-3}\,mol = \underline{9.99 \times 10^{-3}\,mol}$

b) If the mass of the gas is 0.280 g, calculate its relative molecular mass. (1)

Molar mass $= \frac{0.280\,g}{9.987966 \times 10^{-3}\,mol} = 2.803373 \times 10^{1}\,g\,mol^{-1}$

$\therefore$ RMM $= \underline{28.0\,g\,mol^{-1}}$ to 3 s.f.

3) An unknown gas is compared to nitrogen in a piece of apparatus known as a *gas density balance*. This is used to find the pressure at which two different gases have the same density. The balance compartment is first filled with nitrogen to a pressure of 8.31 kPa and then evacuated before filling with an unknown gas, X, until the mass of an equal volume of X is the same as that of the nitrogen. The pressure is then found to be 1.773 kPa. Calculate the relative molecular mass of the unknown gas given that the relative molecular mass of nitrogen is 28.0 and that $D = PM/RT$ (3)

Since $D_{N_2} = D_X$

$\frac{P_{N_2} M_{N_2}}{RT} = \frac{P_X M_X}{RT}$

$\therefore M_X = \frac{P_{N_2} M_{N_2}}{P_X}$

$= \frac{8.31\,kPa}{1.773\,kPa} \times 28.0$

$= 1.31235... \times 10^2$

$= \underline{131}$ to 3 s.f.

4) This question concerns an experiment to determine the gas constant, R. $103.5\,cm^3$ of oxygen are collected over water at a temperature of 30°C. The mass of the oxygen is 0.130 g and atmospheric pressure is 770 mmHg. Given that the vapour pressure of water at this temperature is 32 mmHg and the relative atomic mass of oxygen is 16.0,

a) calculate the number of moles of oxygen present. (1)

$\therefore n = \frac{mass}{molar\ mass} = \frac{0.130\,g}{2 \times 16.0\,g\,mol^{-1}} = \underline{4.0625 \times 10^{-3}\,mol}$

(11)

b) calculate the value of R in $dm^3\,atm\,mol^{-1}\,K^{-1}$. (Note that this value will differ from the expected one since the experiment is not perfectly accurate.) (4)

$PV = nRT$

$\therefore R = \frac{PV}{nT}$

But $P_{H_2O} + P_{O_2} = P_{AT}$

$\therefore P_{O_2} = P_{AT} - P_{H_2O}$

$= 770\,mmHg - 32\,mmHg$

$= \frac{770-32}{760}\,atm$

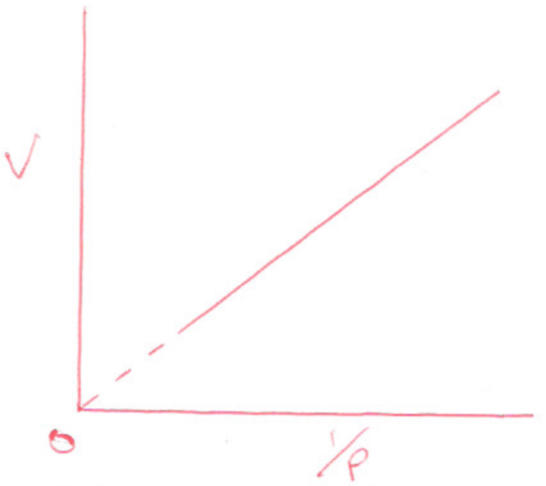
$\therefore n = \frac{\left(\frac{770-32}{760}\right) atm \times 0.35\times10^{-3}\,dm^3}{4.0625\times10^{-?}\,mol \times (273+30)\,K}$

8.164829×10^{-2}

$= 0.0816\,dm^3\,atm\,mol^{-1}\,K^{-1}$ to 3 s.f.

5) Sketch graphs to illustrate:

i) Boyle's Law



ii) Charles's Law

(3 marks each)

6) In order to make an atomic bomb, natural uranium, which is mostly ^{238}U but contains a small proportion of ^{235}U, must be enriched so that it consists mainly of this isotope. The result is known as "weapons grade uranium". One method of achieving this is to subject $UF_6(g)$ to diffusion.

a) Which would you expect to diffuse faster, $^{235}UF_6$ or $^{238}UF_6$? Explain. (3)

$^{235}UF_6$ would diffused faster since its molecules move faster and rate of diffusion increases with the speed of molecules.

b) Calculate the relative rates of diffusion of $^{235}UF_6$ and $^{238}UF_6$ given that the relative atomic mass of fluorine is 19.0 and that the relative isotopic masses of ^{235}U and ^{238}U are the same as their mass numbers. (Express your answer to 4 figures.) (3)

Rate of diffusion $\propto \sqrt{\frac{1}{M}}$

$\therefore \frac{R_{^{235}UF_6}}{R_{^{238}UF_6}} = \frac{\sqrt{1/M_{^{235}UF_6}}}{\sqrt{1/M_{^{238}UF_6}}} = \sqrt{\frac{M_{^{238}UF_6}}{M_{^{235}UF_6}}} = \sqrt{\frac{238+6\times19.0}{235+6\times19.0}}$

$= 1.004288\ldots = 1.004$ to 4 s.f.

c) Suggest why the production of weapons grade uranium must be a lengthy and expensive process. (2)

This is only a tiny degree of enrichment. It must be repeated many times to produce considerable enrichment.

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