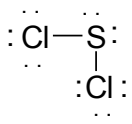
Sample: Chemistry - Molecula Formulae

TASK 1:
Draw a valid Lewis structure for SCl_2.
ANSWER:



TASK 2:
State the electron-pair geometry for SCl_2.
ANSWER:
Sulfur has six valence electrons, plus 14 for two chlorines for a total of 20 electrons. From the Lewis structure we can see two bonds and two lone pairs on sulfur.
This will give tetrahedral electron pair geometry.

TASK 3:
State the molecular geometry for SCl_2.
ANSWER:
There are two bonds and 2 lone electron pairs that's why the molecular geometry is bent.

TASK 4:
Does SCl_2 have a dipole moment?
ANSWER:
Yes. Bent molecules have dipole moment.

TASK 5:
Haemoglobin is the protein that transports O_2 through the blood from the lungs to the rest of the body. In doing so, each molecule of haemoglobin combines with four molecules of O_2. If 1.00 g haemoglobin combines with 1.53 mL O_2 at 37 °C and 743 torr, what is the molar mass of haemoglobin?
SOLUTION:
$Hb + 4O_2 \rightarrow Hb(O_2)_4$
We have to find the number of moles of O_2 first. Let's use Ideal Gas Law:
$pV = nRT$
p- pressure (atm)
V- volume (L)
n- number of moles
R- universal gas constant (0.08206 atm · L / (mol · K))
T- temperature (K)
Let's convert units:
$V = 1.53 \text{ mL} = 1.53 \cdot 10^{-3} \text{ L}$
$P = 743 \text{ torr} = 743 \cdot (1/760) = 0.978 \text{ atm}$

T = 37 °C = 37 + 273 = 310 K
The number of moles of O_2 is
$n(O_2) = pV / RT = (0.978 \cdot 1.53 \cdot 10^{-3}) / (0.08206 \cdot 310) = 5.88 \cdot 10^{-5}$ mol
According to the equation above, the number of moles of O_2 is four times greater than the number of moles of Haemoglobin.
$n(Hb) = n(O_2) / 4 = 5.88 \cdot 10^{-5} / 4 = 1.47 \cdot 10^{-5}$ mol
The molar mass of haemoglobin is
$MW(Hb) = m(Hb) / n(Hb) = 1.00 / (1.47 \cdot 10^{-5}) = 6.80 \cdot 10^4$ g/mol

ANSWER: $MW(Hb) = 6.80 \cdot 10^4$ g/mol

TASK 6:
Nicotine, extracted from tobacco leaves, is a liquid completely miscible with water at temperatures below 60 °C.
(a) A nicotine solution of 0.242 mol/L can be prepared from dissolving 1.921 g of nicotine in 48.92 mL of water. Assuming the volume of the water is equal to that of the solution, what must be the molar mass (in g/mol) of nicotine. (Hint: molar mass of nicotine is the mass of one mole of nicotine).

SOLUTION:
The formula for molarity of solution is
C(mol/L) = n(mol) / V(L)
The number of moles is
n(mol) = m(g) / MW(g/mol)
then
C(mol/L) = n(mol) / V(L) = m / (MW · V)
The molar weight of nicotine is
MW(g/mol) = m(g) / (C(M) · V(L))
MW – molar weight of nicotine (g/mol)
C- molarity of solution (mol/L)
m – mass of nicotine (g)
V- volume of solution (L)
$MW(nicotine) = m(g) / (C(M) \cdot V(L)) = 1.921 / (0.242 \cdot 48.92 \cdot 10^{-3}) = 162$ g/mol

ANSWER: MW(nicotine) = 162 g/mol

(b) Combustion analysis shows nicotine to consist of 74.03% carbon, 8.70% hydrogen and 17.27% nitrogen by mass. What is molecular formula of nicotine?
(Molar masses in g/mol: C = 12.01, H = 1.008, N = 14.01)
SOLUTION:
The general formula of nicotine is $C_xH_yN_z$
The ratio of indexes (x, y, z) is equal to the ratio of moles of each element.

If the mass of nicotine is 100 g, then the mass of carbon is 74.03 g, the mass of hydrogen is 8.70 g, the mass of nitrogen is 17.27 g.
The number of moles is n(mol) = m(g) / MW(g/mol)

$$x : y : z = n(C) : n(H) : n(N) = \frac{m(C)}{MW(C)} : \frac{m(H)}{MW(H)} : \frac{m(N)}{MW(N)} = \frac{74.03}{12.01} : \frac{8.70}{1.008} : \frac{17.27}{14.01}$$

$$= 6.164 : 8.631 : 1.233 = 5 : 7 : 1$$

The brutto formula of nicotine is C_5H_7N. It has the molar mass

$$MW = 5 \cdot 12.01 + 7 \cdot 1.008 + 14.01 = 81.12 g / mol$$

But as we found out in the previous task the molar mass of nicotine is 162 g/mol. It's twice the mass of brutto formula. That's why the molecular formula of nicotine is $C_{10}N_{14}N_2$.

ANSWER: Molecular formula of nicotine is $C_{10}N_{14}N_2$