Example 1.03

An automobile driven by an internal combustion engine burns 10 kmol of gasoline[2] consisting of 100% octane (C_8H_{18}) and converts it completely to carbon dioxide and water vapour by a combustion reaction, whose stoichiometric equation is:

$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$ *Reaction 1.01*

All CO_2 and H_2O produced in the reaction is discharged to the atmosphere via the engine's exhaust pipe (i.e. zero accumulation).
Assume CO_2 content of input combustion air = zero.

Problem.

What is the amount of carbon dioxide discharged to the atmosphere from 10 kmol octane? [Answer in kg of CO_2]

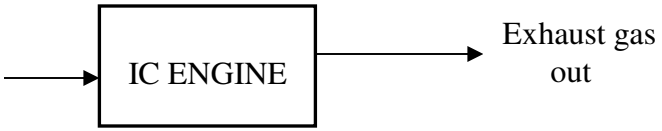
Solution

First note that the amount (mass or moles) of CO_2 is not a conserved quantity. Chemical reactions involve the consumption of reactant species and the generation of product species, so that no species appearing in the stoichiometric equation is conserved when a reaction occurs.

Define the system = automobile internal combustion engine
Specify the quantity = mol (kmol) of CO_2. [mole quantities give the simplest calculations for chemical reactions]

Write the balance equation

ACC of CO_2 in system	=	IN of CO_2 to system	- OUT of CO_2 from system	+ GEN of CO_2 in system	- CON of CO_2 in system



Interpret the Terms

Accumulation of CO_2 in system = 0 kmol (all CO_2 is discharged)
Input of CO_2 to system = 0 kmol (zero CO_2 enters engine)
Output of CO_2 from system = unknown = X kmol
Generation of CO_2 in system = (16/2) (consumption of C_8H_{18} in system)
= (16/2) (10 kmol) = 80 kmol (from stoichiometry of reaction 1.01)
Consumption of CO_2 in system = 0 kmol (CO_2 is a product, not a reactant)

Substitute values for each term into the general balance equation.

$$0 = 0 - X + 80 - 0$$

Solve the balance equation for the unknown "X".

X = 80 kmol CO_2 discharged to atmosphere.
= (80 kmol)(((1)(12.01)+(2)(16.00)) kg/kmol) = **3521 kg CO_2**

[2] kmol ≡ kilomole ≡ molar mass (molecular weight) expressed as kilograms.
1 kmol C_8H_{18} = [(12.01)(8)+(1.008)(18)] = 144.22 kg ≡ 162 litres ≡ 43 US gallons. i.e. 1 kmol is about 3 tanks of gasoline (a.k.a. petrol) for a family car.