

## 3.2 CO<sub>2</sub> Production by Automobiles

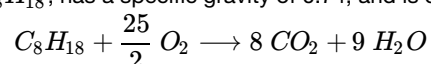
### Summary

This notebook demonstrates the solution of a mass balance for a vehicle powered by an internal combustion engine.

### Examples

#### How much CO<sub>2</sub> is generated per mile driven with an ICE?

A recent model automobile is advertised with a fuel consumption of 30 miles per gallon of gasoline. Assume gasoline consists of pure octane  $C_8H_{18}$ , has a specific gravity of 0.74, and is consumed via the chemical reaction



How much  $CO_2$  is generated per mile driven? Report your answer in grams/mile.

#### Solution

In [1]:

```
liters_per_m3 = 1000.0
gallons_per_m3 = 264.17

V_lpm = (1.0*liters_per_m3/gallons_per_m3)/30.0      # volume of gasoline in liters/mile
m_kg = 0.74*V_lpm                                    # mass of gasoline in kg/mile
m_grams = m_kg*1000.0                                # mass of gasoline in grams/mile
n_octane = m_grams/114.0                             # moles of gasoline in gmol/mile
n_co2 = 8.0*n_octane                                 # moles of CO2 in gmol/mile
m_co2 = 44.0*n_co2                                   # mass of CO2 in grams/mile

print("Gasoline consumed per mile = ", round(m_grams,1), "g/mile")
print("Gram moles of octane per mile = ", round(n_octane,3), "gmol/mile")
print("CO2 Production = ", round(m_co2,1), "g/mile")
```

```
Gasoline consumed per mile = 93.4 g/mile
Gram moles of octane per mile = 0.819 gmol/mile
CO2 Production = 288.3 g/mile
```

#### How much CO<sub>2</sub> is generated per mile driven by an electric car?

Owners of the Tesla S electric car report an average electricity consumption of 0.367 kilowatt-hours per mile driven.

Assume the electricity is produced from natural gas which, [according to the U.S. Energy Information Administration](#), produces 117.0 pounds of  $CO_2$  per million BTU consumed, and requires 10,400 BTU to produce a kilowatt-hour of electricity. Assume an overall transmission efficiency of 80% from the power plant to the Tesla motor. How many grams of  $CO_2$  are generated per mile driven by the Tesla?

#### Solution

In [2]:

```
grams_per_lb = 453.593

w_kwh = 0.367                # kwh per mile
q_btu = (w_kwh/0.8)*10400.0  # natural gas per mile

print("Thermal energy requirement =",round(q_btu,2),"BTU per mile driven")
```

Thermal energy requirement = 4771.0 BTU per mile driven

In [3]:

```
m_co2_lb = 117.0*q_btu/1.0e6      # mass CO2 lb/mile
m_co2_grams = m_co2_lb*grams_per_lb  # mass CO2 grams/mile

print("CO2 Production =", round(m_co2_grams,2), "grams per mile")
```

CO2 Production = 253.2 grams per mile