(3.3) Assuming that in the fission of a uranium atom an energy amount of 200 MeV is released, how far would 1 g of ^{235}U drive a car which consumes 1 liter of gasoline (density 0.70 g cm^{-3}) for each 10 km? The combustion heat of octane is 5500 kJ $mole^{-1}$, and the combustion engine has an efficiency of 18%.

We assume 100% efficiency for energy from uranium. In reality it would probably be more like the ~35% achieved in nuclear ships.

The molar weight of n-octane (C_8H_{18}) can be estimated as:

$MeV := 1.60217733 \cdot 10^{-13} \cdot joule$ $\qquad M_C := 12.01 \cdot gm \cdot mole^{-1}$ $\qquad M_H := 1.008 \cdot gm \cdot mole^{-1}$

$M_{oct} := 8 \cdot M_C + 18 \cdot M_H$ $\qquad M_{oct} = 114.224 \cdot gm \cdot mole^{-1}$

Its combustion energy, H_{oct}, is then:

$H_{comb} := 5500 \cdot 10^3 \cdot joule \cdot mole^{-1}$ $\qquad \rho_{oct} := 0.7 \cdot gm \cdot mL^{-1}$

$H_{oct} := \dfrac{\rho_{oct} \cdot H_{comb}}{M_{oct}}$ $\qquad H_{oct} = 3.371 \cdot 10^7 \cdot joule \cdot liter^{-1}$ (1 liter can move the car 10 km)

Approximating the fission energy of 1 ^{235}U atom by 200 MeV, eqn. (19.1) on p. 518, the nuclear energy, Q, is:

$M_{U235} := 235 \cdot gm \cdot mole^{-1}$ $\qquad N_A := 6.0221367 \cdot 10^{23} \cdot mole^{-1}$ $\qquad Q_{fiss} := 200 \cdot MeV$

$Q := Q_{fiss} \cdot \dfrac{1}{M_{U235}} \cdot N_A$ $\qquad Q = 8.212 \cdot 10^{10} \cdot joule \cdot gm^{-1}$ $\qquad H_{oct} = 3.371 \cdot 10^7 \cdot joule \cdot liter^{-1}$

$dist := \dfrac{1 \cdot gm \cdot Q}{1 \cdot liter \cdot H_{oct} \cdot 0.18} \cdot 10 \cdot km$ $\qquad dist = 135347 \cdot km$

(In case we use the nuclear thermal efficiency typical for nuclear ships, 35%, we would get:

$$\frac{1 \cdot gm \cdot Q \cdot 0.35}{1 \cdot liter \cdot H_{oct} \cdot 0.18} \cdot 10 \cdot km = 47371) \cdot km$$