Engl 3550 War and Peace – Physics Section
Fall 2016
In Class Assignment 2

Introduction

Suppose you want to buy some widgets. They come in packs of 8. If you buy 12 packs, how many widgets do you get? Clearly the answer is 96, which you obtain by multiplying the numbers together

$$\text{number of objects} = \frac{\text{number of objects}}{\text{unit}} * \text{number of units}$$

The questions in this assignment follow the same logic, where the object is now energy rather than a widget, and the unit is a reaction not a widget, and the unit is a reaction not a package.

Units

One catch to watch, the units of energy on the two sides of the equation have to consistent. So you may have to convert to achieve this

- 1 eV = 1.5×10^{-19} J
- 1 MeV = 1.5×10^{-13} J
- 1 ton of TNT = 4.18×10^{9} J

Remember also the 1 W = 1 J/s

Assignment

1. One chemical reaction typically releases about 2 eV of energy. What is that in joules? 3.2×10^{-19} J

2. One nuclear (fission) reaction typically releases about 5 MeV of energy. What is that in joules? 8×10^{-13} J

3. If you want to build a 100 MW power station based on molecular chemical processes
   a. How many reactions per second are needed?
      i. 100 MW = 10^{8} J/s = 3.2×10^{-19} J per reaction * number of reactions per second
      ii. number of reactions per second = $10^{8} / 3.2 \times 10^{-19} = 3.125 \times 10^{26}$ per second.
   b. If each molecular weight is 2×10^{-26} kg, how much fuel is needed in a day?
      i. Mass per second = 2×10^{-26} kg * 3.125×10^{26} per second = 6.25 kg per second
      ii. Total mass = 6.25 kg/s * 86,400 s = 540,000 kg (about 530 tons)

4. If you want to build a power station based on nuclear processes
   a. How many reactions per second are needed?
      i. 100 MW = 10^{8} J/s = 8×10^{-13} J per reaction * number of reactions per second
      ii. number of reactions per second = $10^{8} / 8 \times 10^{-13} = 1.25 \times 10^{20}$ per second.
   b. If each nuclear weight is $235 * 1.66 \times 10^{-27}$ kg, how much fuel is needed in a day?

i. Mass per second = 235*1.66x10^{-27} kg * 1.25 × 10^{20} per second = 4.9 x 10^{-5} kg per second
ii. Total mass = 4.9 x 10^{-5} kg/s * 86,400 s = 4.2 kg (less than 10 pounds)

5. Which releases more energy, a 20 kiloton nuclear bomb (about the size of each bomb dropped on Japan) or a 250 MW nuclear power station operating for 30 years?
   a. Bomb
      i. 20 kilotons = 20,000 * 4.18 x 10^9 J = 8.36 x10^{13}
   b. Power station
      i. 250 x 10^6 * 30 * 365 * 24 * 60 * 60 = 2.37 x 10^{17} J
   c. Power station is more energetic