Jake Stowe - Pset 1

```
<< PhysicalConstants`
```

General::obspkg : PhysicalConstants` is now obsolete. The legacy version being loaded may conflict with current functionality. See the Compatibility Guide for updating information.

2.1)

a)

```
(6.022 * 10^23) * (10^-24)
```

0.6022

b)

```
WolframAlpha["seconds in a nanocentury", "WolframResult"]
```

3.156 s

```
(60 * 60 * 24 * 365 * 100 * 10^-9) // N
```

3.1536

2.2)

```
floppys = (10^12) / (10^6)
```

1 000 000

```
Quantity[floppys * 3 / 10^3, "m"]
```

3000 m

2.3)

```
Sum[2^i, {i, 0, n}]
```

$-1 + 2^{1+n}$

```
2^(1 + 10^70)
```

General::ovfl : Overflow occurred in computation. >>

2.4)

```
g1 = 9.8;
```

```
g2 = (6.673 * 10^-11)
```

6.673 × 10^{-11}

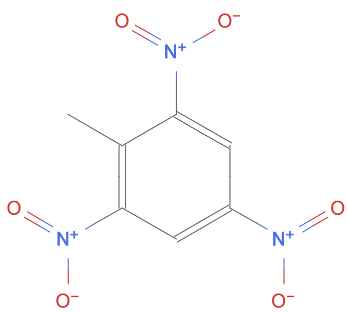
```
decibles = 20 Log[g1 / g2]
```

514.255

2.5)

a)

```
ChemicalData["TNT"]
```




```
ChemicalData["TNT", "MolecularMass"]
```

227.131 u

```
(1.602 * 10^-19) (3) (6.022 * 10^23) (1000) / (227)
```

1.27497 × 10^{6}

b)

```
ElementData["Uranium", "KnownIsotopes"]
```

{217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228,
229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242}

Assume seven divisions 2^7

```
Solve[10^14 == (1.602 * 10^-19) (10^6) (2^7) (6.022 * 10^23) (1000) x / (235), x]
```

{{x → 1.90307}}

c)

```
Solve[Quantity[(10^14), "J"] == m Quantity[1, "SpeedofLight"]^2, m] // N
```

{{m → 0.00111265 kg}}

2.6)

a)

```
velo = Quantity[50, "mph"];
mass = Quantity[100, "g"];
```

```
wvlength = UnitConvert[Quantity[1, "PlanckConstant"] / (velo * mass), "meter"]
```

2.964419×10^{-34} m

b)

```
ChemicalData["Nitrogen"]
```

$N \equiv N$

```
nmass = ChemicalData["Nitrogen", "MolecularMass"]
```

28.0134 u

```
tenergy = UnitConvert[
  (3/2) (Quantity[1, "BoltzmannConstant"] * Quantity[300, "Kelvins"]), "Joules"]
```

6.2129×10^{-21} J

```
nvelo = v /. Solve[(1/2) nmass v^2 == tenergy, v][[2]]
```

516.84 m/s

```
nwavelength =
 UnitConvert[Quantity[1, "PlanckConstant"] / (nmass * nvelo), "Angstroms"]
```

0.27560 Å

c)

```
FormulaData[{"IdealGasLaw", "Density"}]
```

$m P == (R) T \rho$

```
ndens = ρ /.
  First@Solve[ChemicalData["Nitrogen", "MolarMass"] * Quantity[1, "Atmospheres"] ==
     Quantity[1, "MolarGasConstant"] * Quantity[300, "Kelvins"] * ρ, ρ]
```

$1.13796\ kg/m^3$

```
ndensconv = UnitConvert[ndens / nmass, "Nanometers"^3]
```

0.024463/nm^3

```
nvol = 1 / ndensconv
```

40.878 nm^3

```
UnitConvert[2 * r /. Last@Solve[(4 / 3) * π * r^3 == nvol, r], "Angstroms"]
```

42.740 Å

d)

If we assume that the perfect gas law holds at the temperatures we're exploring then we can write

```
UnitConvert[Quantity["MolarGasConstant"], "
```

```
r[T_] := (1 / 2) CubeRoot[((3 / 4 π) * Quantity[1, "MolarGasConstant"] *
    Quantity[1 / (6.022 * 10^23), "Moles"] * T) / (Quantity[1, "Atmospheres"])]
```

```
Solve[r[t] == a, t]
```

Solve::ratnz : Solve was unable to solve the system with inexact coefficients.
The answer was obtained by solving a corresponding exact system and numericizing the result. >>

```
{{t → ConditionalExpression[(2.49174 × 10^28 K/m^3) Re[a]^3,
    (Im[a] == 0 && Re[a] > 0) || (Im[a] == 0 && Re[a] < 0)]}}
```

```
2.4917361702501006`*^28 K/m^3 * nwavelength^3
```

0.000521626 K

2.7)

a)

```
Clear[r]
```

```
Solve[(1 / 2) m1 v^2 == ((Quantity["GravitationalConstant"] m2 m1) / r), v][[2]]
```

Solve::ratnz : Solve was unable to solve the system with inexact coefficients.
The answer was obtained by solving a corresponding exact system and numericizing the result. >>

$$\left\{v \to \frac{(0.00001155\ \mathrm{m/s})\sqrt{m2\,(1\ \mathrm{m^2/(kg\,s)})}\sqrt{r\,(1\ \mathrm{s/m})}}{r}\right\}$$

b)

```
Clear[r]
```

```
mradius =
 First@First@(Solve[(1/2) m1 v^2 == ((Quantity["GravitationalConstant"] m2 m1)/r) /.
      v → Quantity["SpeedOfLight"], r])
```

Solve::ratnz : Solve was unable to solve the system with inexact coefficients.
The answer was obtained by solving a corresponding exact system and numericizing the result. ≫

$r \to m2 \left(1.485 \times 10^{-27}\ \text{m/kg}\right)$

c)

```
mwavelength =
 First@First@Solve[Quantity["PlanckConstant"] (Quantity["SpeedOfLight"] / λ) ==
     m2 Quantity["SpeedOfLight"]^2, λ]
```

Solve::ratnz : Solve was unable to solve the system with inexact coefficients.
The answer was obtained by solving a corresponding exact system and numericizing the result. ≫

$$\lambda \to \frac{2.210219 \times 10^{-42}\ \text{s}^2\text{N}}{\text{m2}}$$

```
mmass = Solve[mradius[[2]] == mwavelength[[2]], m2][[2]]
```

Solve::ratnz : Solve was unable to solve the system with inexact coefficients.
The answer was obtained by solving a corresponding exact system and numericizing the result. ≫

$\{m2 \to 3.858 \times 10^{-8}\ \text{kg}\}$

d)

```
mradius /. mmass
```

$r \to 5.73 \times 10^{-35}\ \text{m}$

```
UnitConvert[Quantity["PlanckLength"], "Meters"]
```

$1.616 \times 10^{-35}\ \text{m}$

f) out of order

```
mperiod = Quantity["SpeedOfLight"] / (mwavelength[[2]] /. mmass) // UnitSimplify
```

5.23×10^{42} per second

e)

```
UnitConvert[Quantity["PlanckConstant"] * mperiod, "Joules"]
```

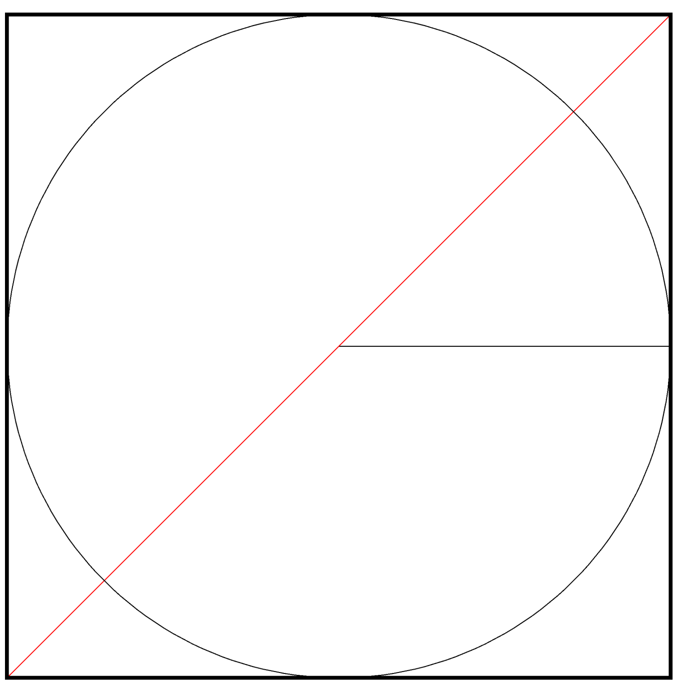
3.467×10^9 J

2.8)

a)

By symmetry, the problem is equivalent ot the two dimensional case of a triangle and circle

```
Graphics[{Sequence[]
  ,
  {Line[{{0, 0}, {1/2, 0}}]
   , Red, Line[{{-1/2, -1/2}, {1/2, 1/2}}]
  }
  , {EdgeForm[{Thick, Black}], Circle[{0, 0}, 1/2]}
  , {Sequence[]
   , FaceForm[{Opacity[0]}]
   , EdgeForm[{Thick, Black}]
   , Rotate[Rectangle[{-1/2, -1/2}], 90 Degree]
  }
 }
]
```



Again we see that the 2d Problem is symmetric by rotation of 60 degrees. hence every side is the same length. So we have

```
sol = First@Solve[h == Sqrt[(l/2)^2 + (l/2)^2], h]
```

$\{h \to \frac{\sqrt{l^2}}{\sqrt{2}}\}$

b)

And we need r of the circle to complete the problem, by inspection we see that

```
rsol = r → l/2
```

$r \to \frac{l}{2}$

```
pts28 = Delete[#, 3] &[Insert[#, #[[2]], 1] &[
    ({#[[1]], #[[2]], 0} & /@ Tuples[{l/2, -l/2}, 2]) ~Join~ {{0, 0, h /. sol}}]]
```

$\{\{\frac{l}{2}, -\frac{l}{2}, 0\}, \{\frac{l}{2}, \frac{l}{2}, 0\}, \{-\frac{l}{2}, \frac{l}{2}, 0\}, \{-\frac{l}{2}, -\frac{l}{2}, 0\}, \{0, 0, \frac{\sqrt{l^2}}{\sqrt{2}}\}\}$

```
pyrvol = Volume[Pyramid[pts28], Assumptions → l > 1]
```

$\frac{l^3}{3\sqrt{2}}$

```
sphvol = (1/2) * Volume[Ball[{0, 0, 0}, r /. rsol]]
```

$\frac{l^3 \pi}{12}$

```
sphvol / pyrvol
```

$\frac{\pi}{2\sqrt{2}}$

```
Graphics3D[{Pyramid[pts28], Ball[{0, 0, 0}, r /. rsol]} /. l → 1]
```