1) (a)

	$T_{1/2}$ (d)	E_γ (keV), I_γ (%)	E_γ (keV), I_γ (%)
^{56}Co	77.236	846.77, 99.94	1238.29, 66.46
^{57}Co	271.74	122.06, 85.6	136.47, 10.68
^{58}Co	70.86	810.7593, 99.45	(511%)
^{60}Co	1925.28	1173.228, 99.85	1332.492, 99.98
^{59}Fe	44.495	1099.245, 56.5	1291.59, 43.2

Data from NNDC Table of Isotopes

(b) from lecture:

$$\text{Activity} = \lambda N \left(= (\text{Prod. Rate})(1 - e^{-\lambda t_1})\, e^{-\lambda t_2}\right.$$

where t_1 = time of bombardment, t_2 = decay time

want $$\frac{A(^{58}Co)}{A(^{59}Fe)} = \cancel{\frac{(\text{Prod Rate})_{58}}{(\text{Prod Rate})_{59}}} \frac{(1 - e^{-\lambda_{58} t_1})}{(1 - e^{-\lambda_{59} t_1})} \frac{e^{-\lambda_{58} t_2}}{e^{-\lambda_{59} t_2}}$$

$t_1 = 14$ week
$t_2 = 8$ week

$$\lambda_{58} = \frac{\ln 2}{70.86\ d / 7\ d/wk} = 6.847\,E{-2}/wk$$

$$\lambda_{59} = \frac{\ln 2}{44.495\ d / 7\ d/wk} = 1.090\,E{-2}/wk$$

$$\frac{A(^{58}Co)}{A(^{59}Fe)} = \frac{\left(1 - e^{-\underbrace{6.847 \times 10^{-2} * 14}_{0.9586}}\right)}{\left(1 - e^{-\underbrace{1.090 \times 10^{-2} * 14}_{1.527}}\right)} e^{+(1.090 \times 10^{-2} - 6.847 \times 10^{-2}) * 8}$$

$$= \frac{0.6166}{0.7827} e^{+0.3246} = 0.7877 * 1.383$$

$$= 1.09 \rightsquigarrow \frac{A(^{59}Fe)}{A(^{58}Co)} = \frac{1}{1.09} = 0.92$$

2) (a) See attached for ^{48}Ca in Ti SRT results

Note - nuclear stopping can be ignored (see values)

Beam KE = $140\ \text{MeV}/u * 48u = 6720.\ \text{MeV}$

window $\Delta E = \frac{dE}{dx}\Delta x \sim 762.2\ \frac{\text{keV}}{\text{micron}} * 500\ \text{micron} = 3.81 \times 10^5\ \text{keV}$

$\Delta E = 3.81 \times 10^2\ \text{MeV}$ (each ion)

Note dE/dx only changes by about 2% going through

(b) $\text{Watts} = \frac{\text{Joule}}{\text{sec}} = \Delta E\ \frac{\text{MeV}}{\text{particle}} * \text{Rate}\ \frac{\text{particle}}{\text{sec}} * \frac{\text{Joule}}{\text{MeV}}$

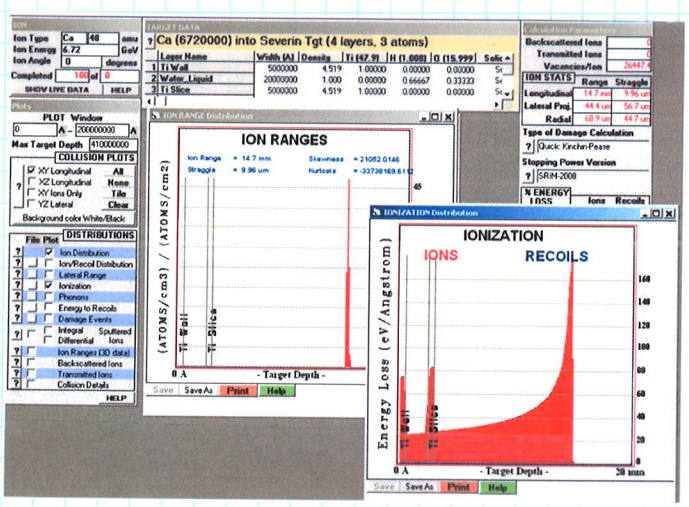
$$\text{Power} = 381\ \frac{\text{MeV}}{\text{part}} * \left(\frac{40. \times 10^{-9}\ A * \frac{\text{Coul/s}}{A}}{20. \times 1.602 \times 10^{-19}\ \frac{\text{Coul}}{\text{part}}} \right) \times 10^6\ \frac{\text{eV}}{\text{MeV}} \times 1.602 \times 10^{-19}\ \frac{J}{eV}$$

$$\text{Power} = 381. * 0.0402 = 0.762\ \text{Watts}$$

[Note MeV × pμA = Watts]

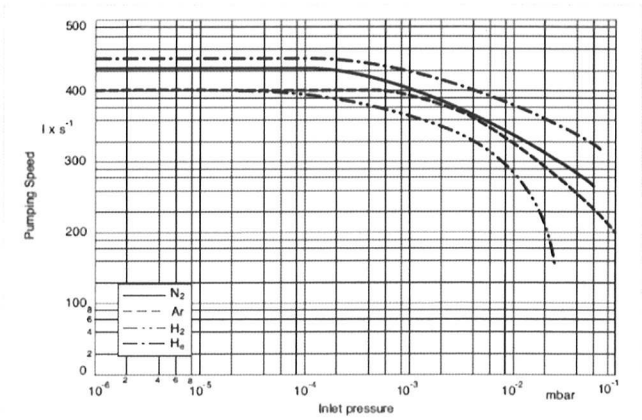
381 × 0.002 = 0.762

(c) See attached for TRIM results, Range = 14.7 mm



```
==========================================================
          Calculation using SRIM-2006
          SRIM version ---> SRIM-2008.03
          Calc. date   ---> September 09, 2019
==========================================================

Disk File Name = SRIM Outputs\Calcium in Titanium

Ion = Calcium [20] , Mass = 48 amu

Target Density =  4.5189E+00 g/cm3 = 5.6812E+22 atoms/cm3
======= Target  Composition ========
  Atom  Atom  Atomic   Mass
  Name  Numb  Percent  Percent
  ----  ----  -------  -------
   Ti    22   100.00   100.00
=====================================
Bragg Correction = 0.00%
Stopping Units =  keV / micron
See bottom of Table for other Stopping units

  Ion      dE/dx     dE/dx    Projected  Longitudinal  Lateral
 Energy    Elec.     Nuclear    Range     Straggling  Straggling
----------- ---------- ---------- ---------- ---------- ----------
  5.00 GeV  8.932E+02  3.117E-01   3.26 mm   132.31 um   22.00 um
  5.50 GeV  8.346E+02  2.859E-01   3.84 mm   155.74 um   25.67 um
  6.00 GeV  7.851E+02  2.642E-01   4.46 mm   178.70 um   29.55 um
  6.27 GeV  7.622E+02  2.538E-01   4.81 mm   185.48 um   31.73 um
-------------------------------------------------------------
Multiply Stopping by       for Stopping Units
--------------------       ------------------
 1.0000E-01                eV / Angstrom
 1.0000E+00                keV / micron
```

Lebold
45ϕi
speed
curve



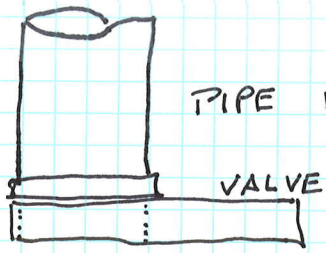
Pumping speed as a function of the inlet pressure for the TURBOVAC T 450 i

3) (a) $Q = q_{HS}\,\text{Area} = q_{HS}\left[2A_{TOP} + 2A_{SIDE_1} + 2A_{SIDE_2} + A_{PIPE}\right]$

$$= 2\times10^{-5}(1)^{-1.3}\left[\underbrace{2\times0.48\times0.45}_{0.432} + \underbrace{2\times0.48\times0.96}_{0.9216} + \underbrace{2\times0.45\times0.96}_{0.864} + \underbrace{\pi\left(\frac{0.16}{2}\right)^2 0.2}_{0.004}\right]$$

$$= 2\times10^{-15}\,\frac{W}{m^2}\left[2.222\ m^2\right] = 4.44\times10^{-5}\ W$$

(b)



PIPE 15cm diameter = 16.0cm } approximate as a straight pipe

VALVE 5cm

$L = 20\,cm$, $R = 8\,cm$ } $\frac{L}{R} = 2.5$

Oatley $C = a\ 11.6\ \frac{l}{s\,cm^2}\ A(cm^2)$ $\quad a \sim 0.45$

$A = \pi(8cm)^2 = 201.1\,cm^2$

$C = 0.45\,(11.6)\,201.1\ \frac{l}{s}$

$C = 1050.\ l/s$

Analytical for N_2 gas $\quad C = \frac{\pi}{12}\,v\,\frac{d^3}{l} = \frac{\pi}{12}\left(475\,\frac{m}{s}\right)\frac{\cancel{0.08}^3\ 0.16^3\ m^3}{0.020\ m} = \cancel{318.}\ 2544.\ \frac{l}{s}$

not a "LONG PIPE"

(c) Leybold 450; found in "full line catalogue" on line p 30 $\quad S = 420\ \frac{l}{s}\ (N_2)$

$$\frac{1}{S_{eff}} = \frac{1}{S} + \frac{1}{C} = \frac{1}{420} + \frac{1}{1050} \rightsquigarrow S_{eff} = \frac{1}{3.33\times10^{-3}}$$

$$S_{eff} = 300.\ l/s$$

(d) $Q = P\,S_{eff} \rightsquigarrow P = \frac{Q}{S_{eff}} = \frac{4.44\times10^{-5}\,W}{0.300\ m^3/s} = 1.48\times10^{-4}\ Pa$

$$P = 1.48\times10^{-4}\,Pa \times \frac{760\,torr}{101325\,Pa} = 1.1\times10^{-6}\ torr$$