Vacuum Experiment: Week 1

AP 4018
Columbia University

Week 1 Objectives

- Learn about vacuum technology, instrumentation, and terminology
- Analyze measurements of pressure vs. time to estimate the pumping speed of the mechanical (“roughing”) backing pump

Introductory Reading

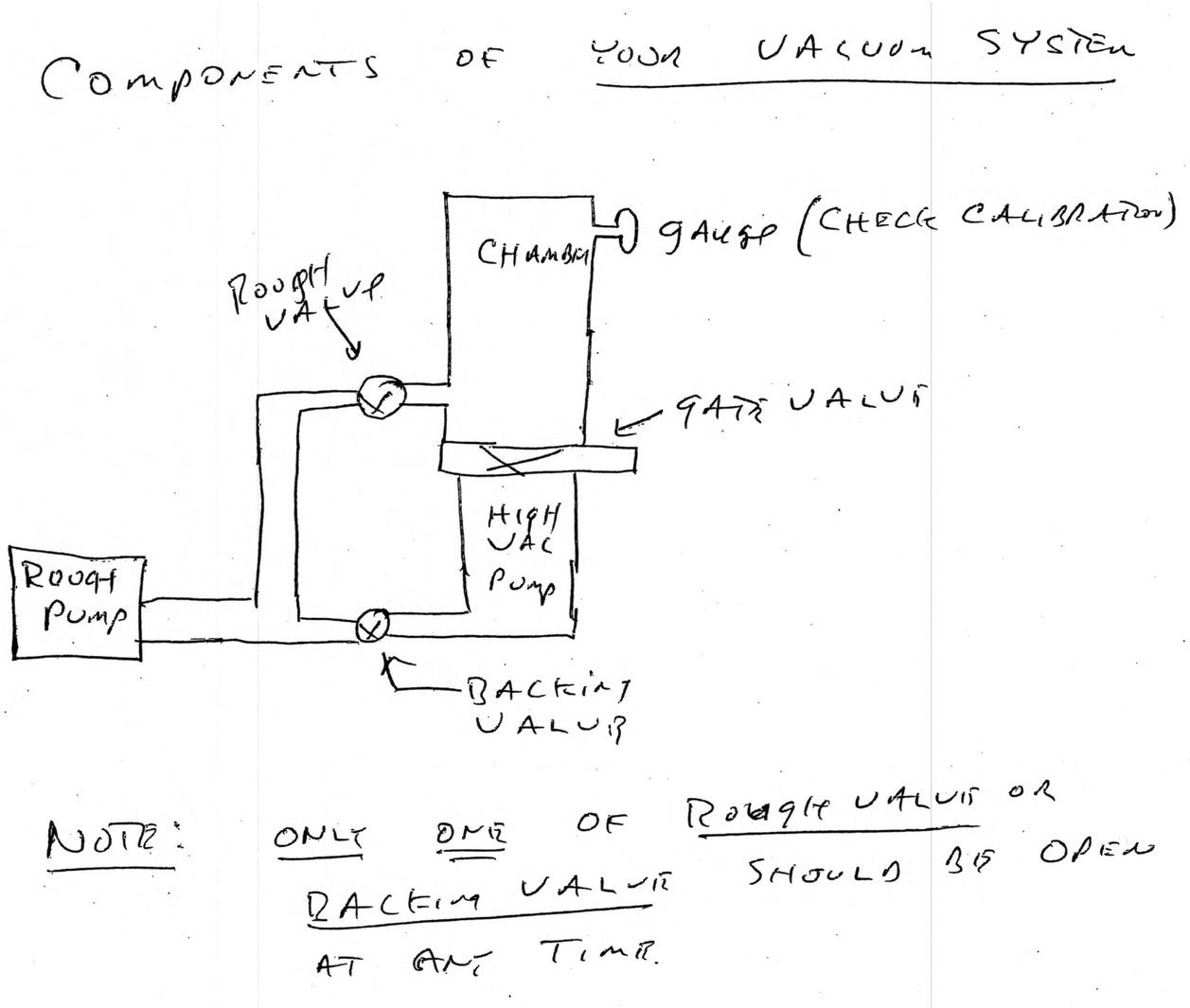
- Please see class homepage at: http://sites.apam.columbia.edu/courses/ap4018y/ and
- Read background information about vacuum science and technology
- Note:

Many facilities for applied physics research and development depend upon removing gas molecules. Examples abound: plasma physics, surface science, cryogenic studies (including quantum computing.) This lab introduces you to vacuum science and technology.

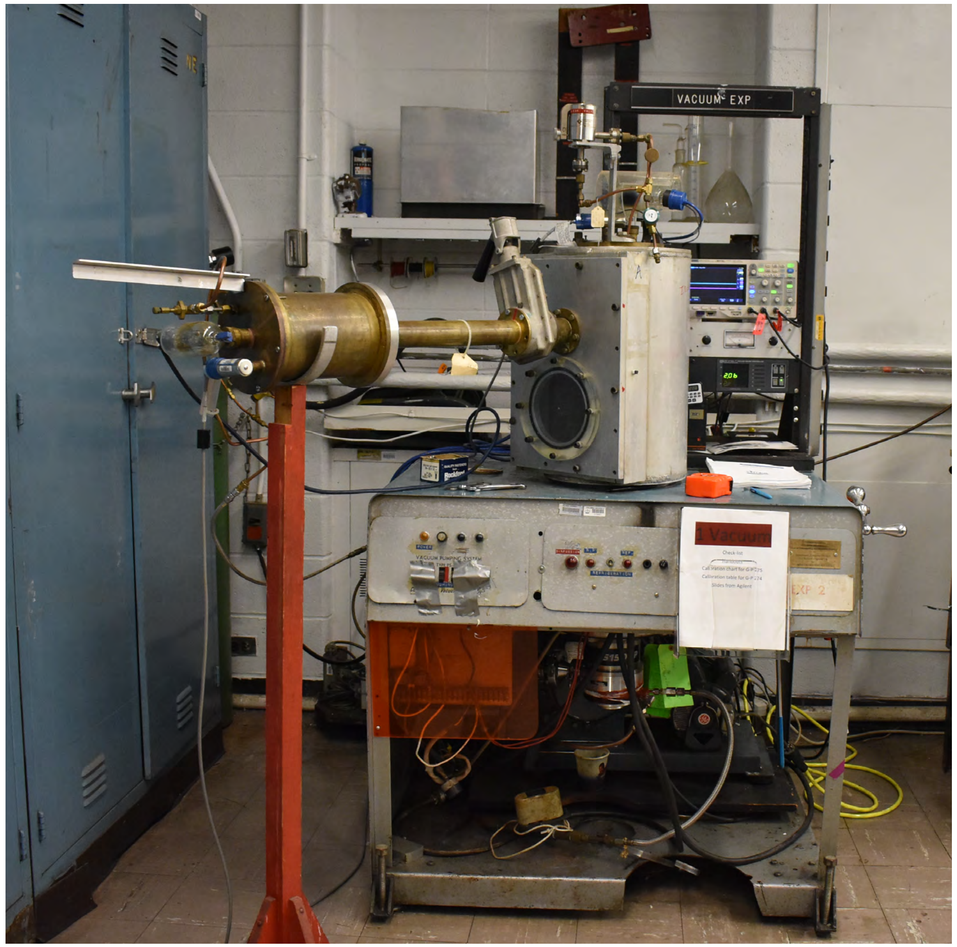
Very Good Introduction…

http://sites.apam.columbia.edu/courses/ap4018y/UHV_Seminar_Handbook.pdf

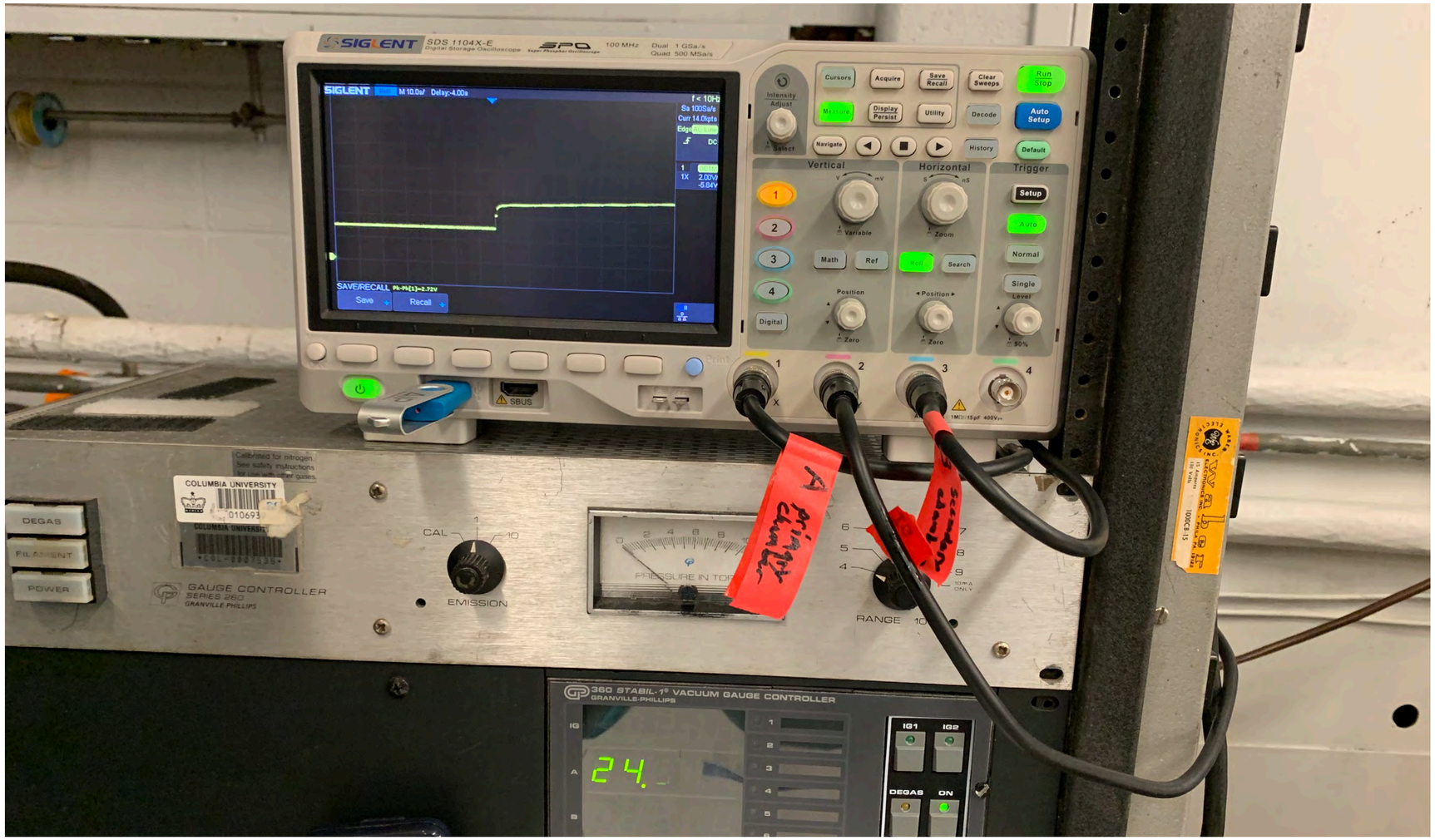
Components of Your Vacuum System



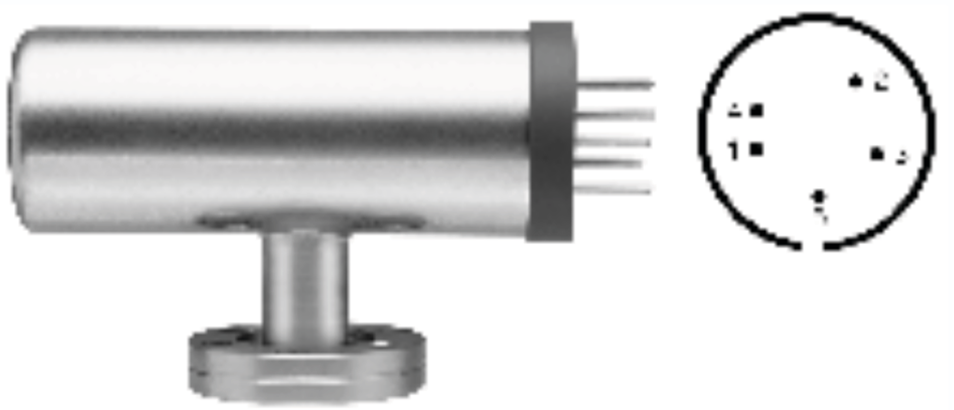
Components of Your Vacuum System



Components of Your Vacuum System



Series 275 Convection Gauge



4.9 Convectron Gauge Analog Output Signal

If the Convectron Gauge capability is installed, a voltage output signal proportional to the common logarithm of the pressure indication is provided on the rear panel of the Convectron Gauge module via a standard 1/8 in. miniature phone jack.

If graphed on log-linear axes, the output voltage is linear with respect to the log of pressure. The analog output is 1 volt per decade of pressure with a factory adjusted output of 0 volts at 1.0×10^{-4} Torr.

The equation is: $Pi = 10^{V-4}$ Torr/mbar, or $Pi = 10^{V-2}$ Pascal

where Pi = pressure indication,

V = analog output voltage

and: the offset is at the factory adjusted 0V at 10^{-4} Torr (10^{-2} Pa).

If the offset has been adjusted to other than 0V at 10^{-4} Torr (10^{-2} Pa), then the exponent value must be forced to -4 (-2 for Pa) when the pressure is at 1.0×10^{-4} Torr (10^{-2} Pa) by adding or subtracting a number other than -4 from the value of V.

Gauge Tube Construction

The transducer is a convection enhanced Pirani gauge providing rapid response, six-decades of pressure transduction, stable calibration, and good accuracy. The Pirani sensing element, R1 of the schematic of Fig. 2-1, is one leg of a Wheatstone Bridge. A temperature compensating network, R2, forms the second leg of the bridge. The temperature sensitive component of this network is mounted inside the gauge tube envelope with the sensor. All other resistors of the bridge are mounted upon the exterior electrical feedthrough pins of the gauge tube. Pin 4 serves as an electrical terminal for construction of the compensating network, R2, but no connection is made therefrom to the controller.

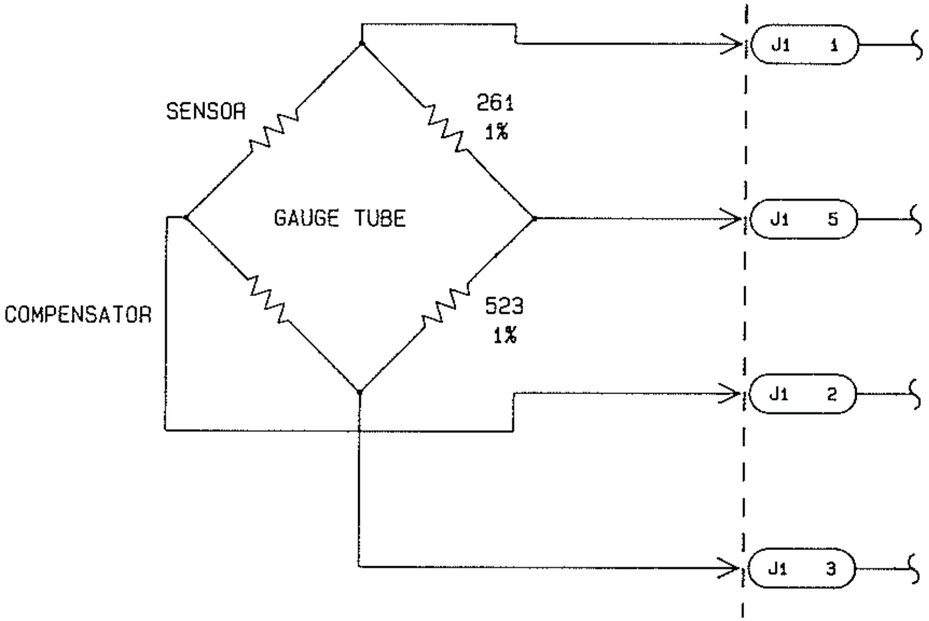


FIG. 2-1 GAUGE TUBE SCHEMATIC

Convectron Gauge is Calibrated for N_2

3-6 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-4} to 10^{-1} Torr

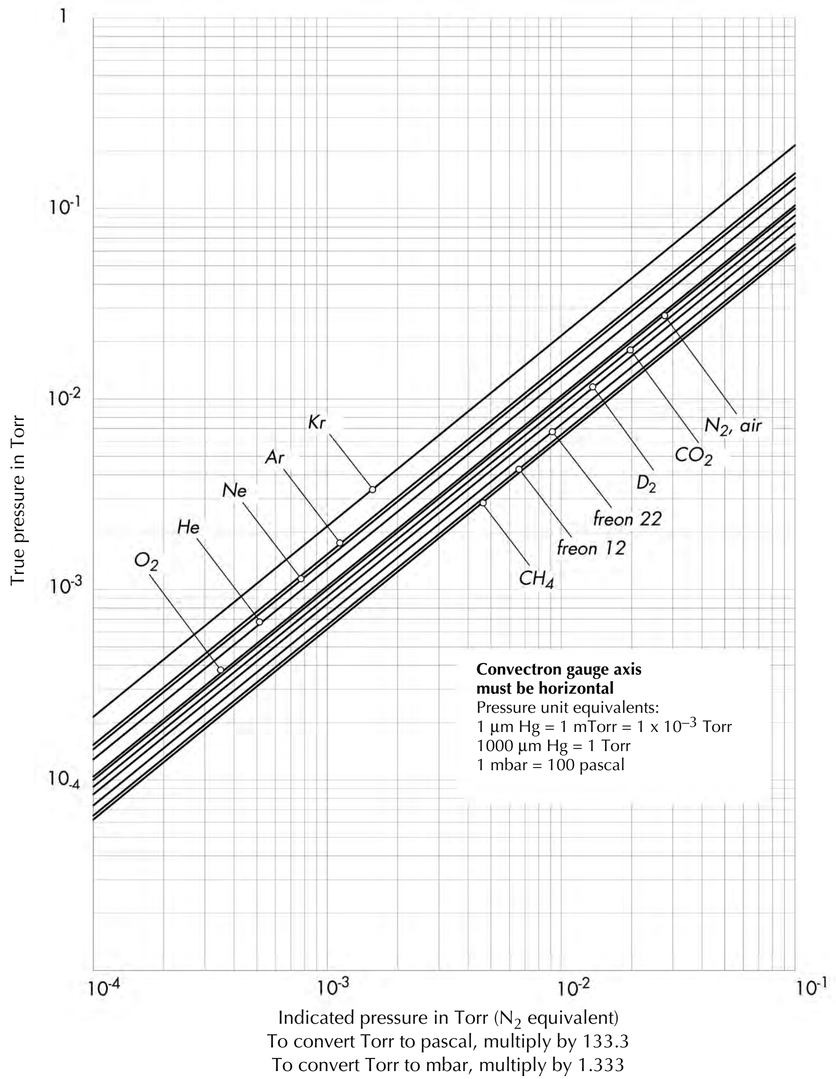
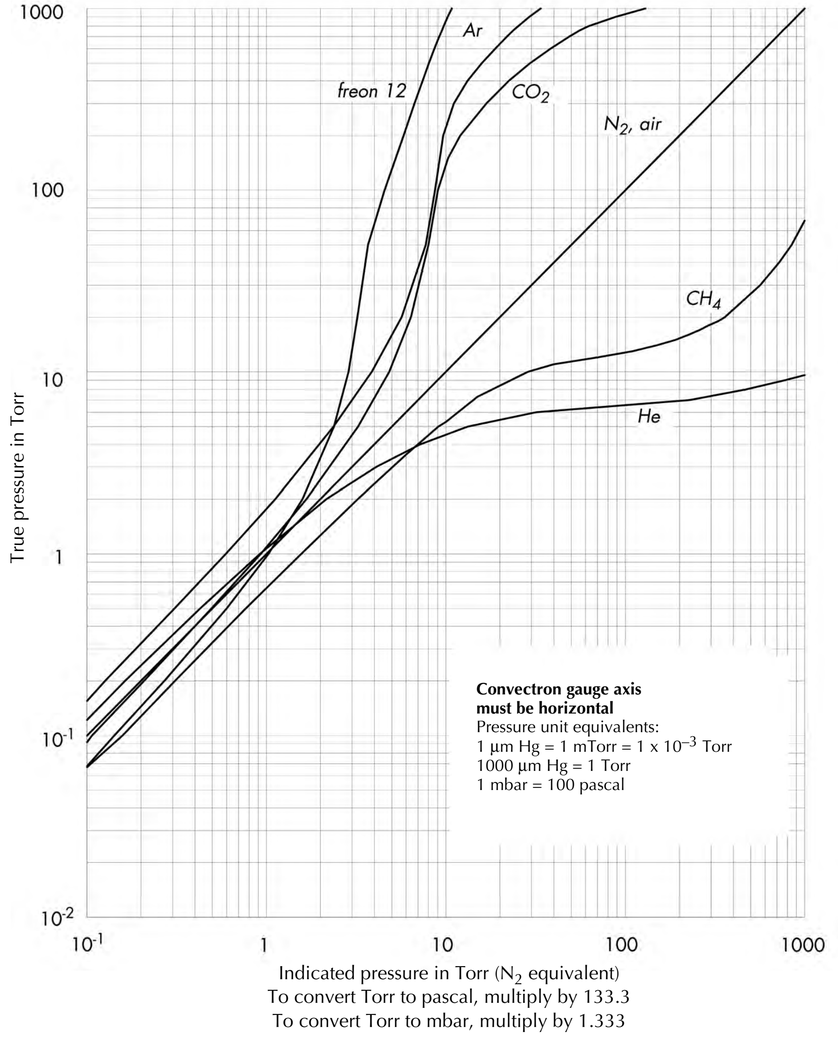


Figure 3-7 True Pressure versus Indicated Pressure for Commonly used Gases, 10^{-1} to 1000 Torr



Procedure

PROCEDURE:

(1) CLOSE ALL VALVES

(2) TURN-ON ROUGHING PUMP + VALVES

(REPEAT) ⟶ (3) MEASURE PRESSURE VS TIME

(4) CLOSE ROUGH VALVE

(5) OPEN BACKING VALVE

(6) TURN ON HIGH VACCUM PUMP

(7) OPEN GATE VALVE

Definition of Pumping Speed

P = PRESSURE (MEASURED IN TORR)

t = TIME (SEC)

S = PUMPING SPEED (LITERS/SEC)

V = CHAMBER VOLUME (LITERS)

WITH PUMP ON...

$$V\frac{dP}{dt} = -SP$$

↑ SPEED IS OFTEN A CONSTANT

THEREFORE

$$P(t) = P(0)\, e^{-St/V}$$

S DEPENDS UPON GAS SPECIE

How Big is the Vacuum Chamber? (V)

$$V =$$