

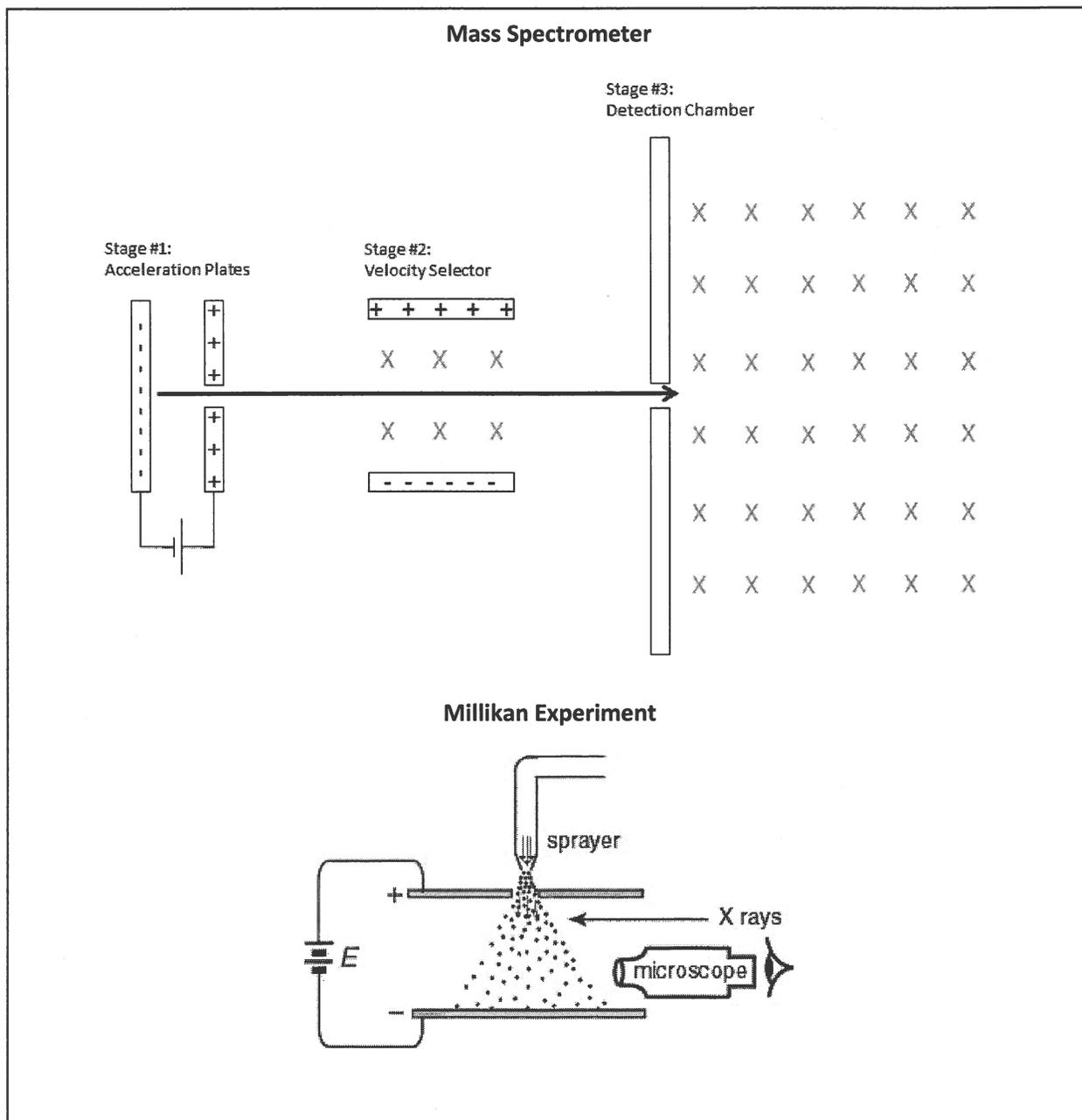
First Name: \_\_\_\_\_

Last Name: \_\_\_\_\_

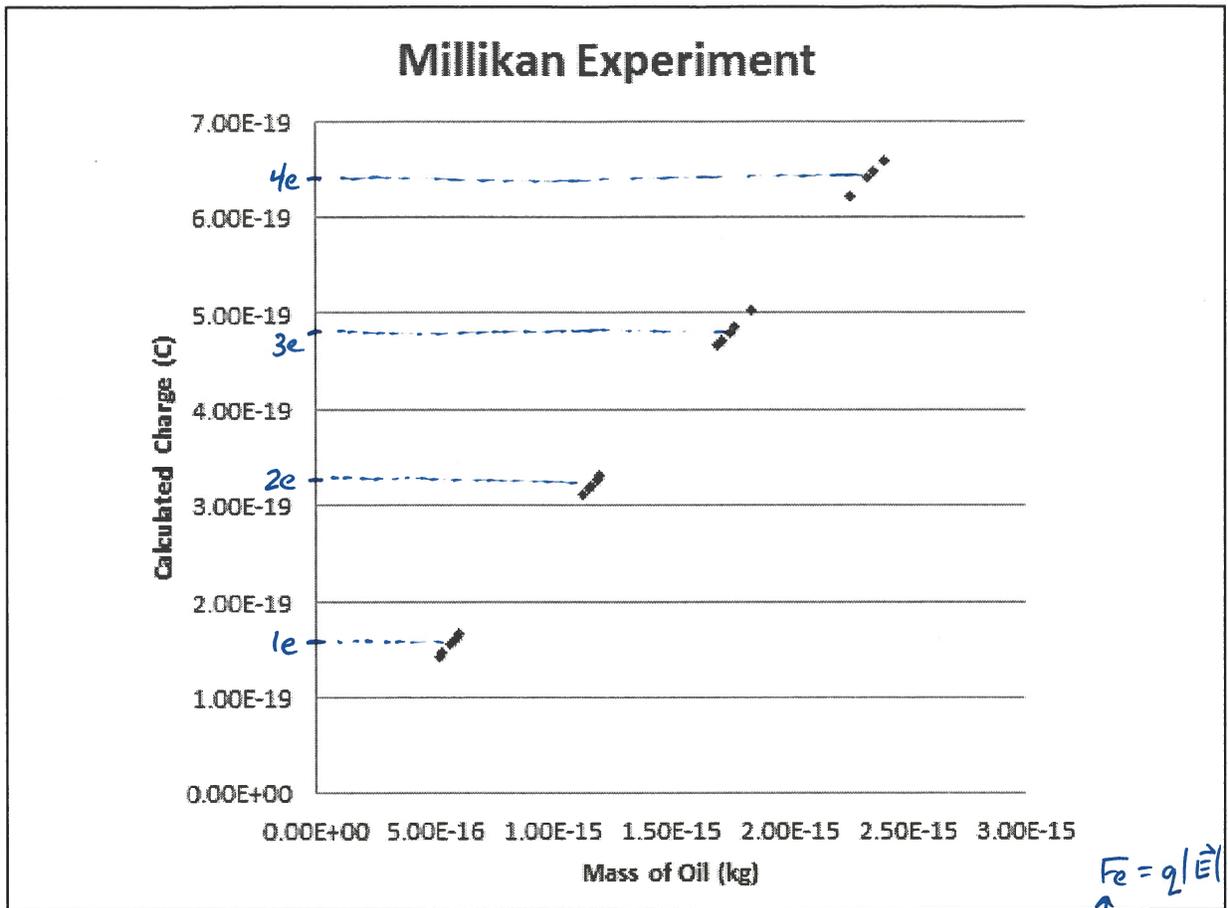
## LO3 – Worksheet – Mass Spectrometer and Millikan's Experiment

NOTE: Completed the homework (Pg 756 #1-3, Pg 758 #1-3, Pg 760 #4-6) first.

Use the following information to answer questions in this worksheet:

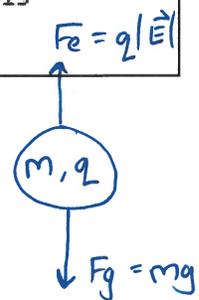


Use the following information to answer Q1 through Q2:



Q1: Which of the following best describes this data?

- a. Continuous and Linear
- b. Continuous and Non-Linear
- c. Discrete and Linear
- d. Discrete and Non-Linear



Explain why: Each "bundle" of data represents oil drops with a certain number of missing/additional electrons. (See chart). Since we can't have partial electrons, there should be no data in this range between integer values of "e", the elementary charge.

Q2: Which of the following quantities best describes the slope?

- a.  $\frac{m}{|E|}$
- b.  $\frac{|E|}{g}$
- c.  $g|E|$
- d.  $\frac{g\Delta d}{\Delta V}$

$F_e = F_g$   
 $q|E| = mg$   
 $q = \left(\frac{g}{|E|}\right)m + 0$   
 $y = (m)x + b$

But not an option! Remember that  $|E| = \frac{\Delta V}{\Delta d}$  so  $\frac{1}{|E|} = \frac{\Delta d}{\Delta V}$   
 and  $q = \left(\frac{g}{|E|}\right)m + 0$  becomes  
 $q = \left(\frac{g\Delta d}{\Delta V}\right)m + 0$  } So slope =  $\frac{g\Delta d}{\Delta V}$

KEY

Q3: Which **Physics Principle** is essential for understanding Millikan's Experiment?

(Record your **one digit** answer in the Numerical Response boxes below)

0			
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0 - Uniform Motion ( $\vec{F}_{net} = 0$ )

Balanced forces! No acceleration!



Use the following information to answer Q4 and Q5:

A potential difference of 340.0 V exists between two plates that are separated by a distance of 95.0 cm, and an oil drop of mass  $1.70 \times 10^{-15}$  kg is suspended between the plates.

Q4: The net charge on the oil drop is  $a.b \times 10^{-cd}$  C. The values of **a**, **b**, **c**, and **d** are \_\_, \_\_, \_\_, and \_\_.

(Record your **four digit** answer in the Numerical Response boxes below).

4	7	1	7
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$$F_e = F_g$$

$$q|\vec{E}| = mg$$

$$q \frac{\Delta V}{d} = mg$$

$$\frac{q(340)}{(95 \times 10^{-2})} = (1.70 \times 10^{-15})(9.81)$$

$$q = 4.65975 \times 10^{-17} = 4.7 \times 10^{-17} \text{ C}$$

Q5: The oil drops charge is caused by:

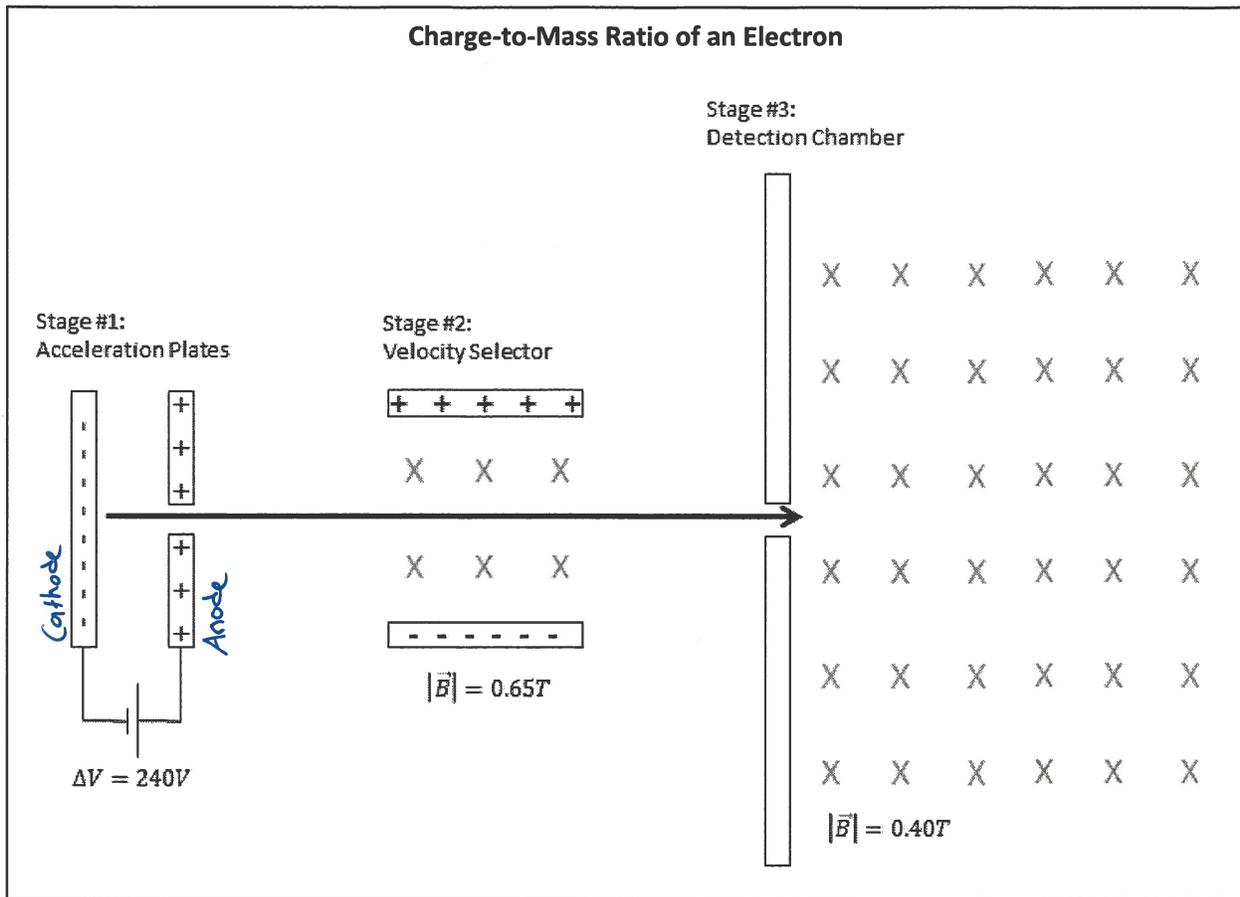
- a. An excess of a discrete number of electrons.
- b. An absence of a discrete number of electrons.
- c. Both **a** and **b**.

(d) Either **a** or **b**, but not both.

Explain why: Unless we know the charge on each plate (is the top plate positive or negative?), we only know that our oil drop would experience an attractive force.

NOTE: If we use the orientation on the first page, then our negative oil drop would have excess electrons, so "A".

Use the following information to answer Q6 through Q10:



**Q6:** The first stage of a mass spectrometer involves accelerated a particle from rest at the i towards the ii. Upon exiting, it travels forward to the velocity selector. Because of where these particles originated, they were originally referred to as iii. Today we call them iv.

Select the row the best completes the above sentence.

	<i>i</i>	<i>ii</i>	<i>iii</i>	<i>iv</i>
A.	Anode	Electrode	Anode rays	Electrons
B.	Cathode	Electrode	Cathode rays	Positrons
C.	Anode	Cathode	Anode rays	Positrons
<b>D.</b>	Cathode	Anode	Cathode rays	Electrons

**Q7:** To determine the speed of the charged particles as they exit the acceleration plates, we could calculate this using either Physics Principle *a* or Physics Principle *b*, where the values of *a* and *b* are \_\_\_ and \_\_\_.

(Record your two digit answer in the Numerical Response boxes below).

(or "15")

5- Conservation of Energy

$$E_p \rightarrow E_k$$

$$q\Delta V = \frac{1}{2}mv^2$$

1- Accelerated Motion

$$|\vec{E}| = \frac{\Delta V}{\Delta d}$$

$$|\vec{F}| = q|\vec{E}|$$

$$a = \frac{F_{net}}{m}$$

$\rightarrow V_f^2 = v_i^2 + 2ad$   
 (Requires knowing plate separation distance).

KEY

Q8: Upon exiting the acceleration plates, the charged particle beam is travelling at  $a.bc \times 10^d$  m/s, where  $a$ ,  $b$ ,  $c$ , and  $d$  are \_\_, \_\_, \_\_, and \_\_.

(Record your four digit answer in the Numerical Response boxes below).

9	1	8	6
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$$E_p \rightarrow E_k$$

$$q\Delta V = \frac{1}{2}mv^2$$

$$(1.60 \times 10^{-19} \text{ C})(240 \text{ V}) = \frac{1}{2}(9.11 \times 10^{-31})v^2$$

$$v^2 = 8.43 \times 10^{13}$$

$$v = 9.18 \times 10^6 \text{ m/s}$$

Q9: To pass through the velocity selector undeflected, the electric field strength is  $a.bc \times 10^d$  N/C, where  $a$ ,  $b$ ,  $c$ , and  $d$  are \_\_, \_\_, \_\_, and \_\_.

(Record your four digit answer in the Numerical Response boxes below).

5	9	7	6
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$$F_m = F_e$$

$$qv|\vec{B}| = q|\vec{E}|$$

$$(9.181664... \times 10^6)(0.65) = |\vec{E}|$$

$$|\vec{E}| = 5.96808195281 \times 10^6 \text{ N/C}$$

$$= 5.97 \times 10^6 \text{ N/C}$$

Q10: Inside the detection chamber the charged particles have a radius of curvature of  $a.bc \times 10^d$  m, where  $a$ ,  $b$ ,  $c$ , and  $d$  are \_\_, \_\_, \_\_, and \_\_.

(Record your four digit answer in the Numerical Response boxes below).

1	3	1	4
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$$F_m = qv|\vec{B}| \quad F_c = \frac{mv^2}{r}$$

$$qv|\vec{B}| = \frac{mv^2}{r}$$

$$q|\vec{B}| = \frac{mv}{r}$$

$$r = \frac{mv}{q|\vec{B}|} = \frac{(9.11 \times 10^{-31})(9.18166454278 \times 10^6)}{(1.60 \times 10^{-19})(0.40)}$$

$$r = 1.30695256226 \times 10^{-4} \text{ m}$$

$$= 1.31 \times 10^{-4} \text{ m}$$