[redacted] KEY [redacted]

First Name:______________________________ Last Name:________________________________

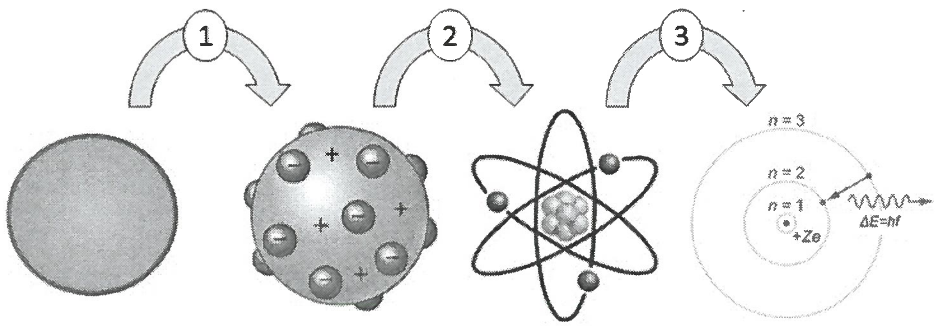
L04 – Worksheet – Review of the Atomic Model

KEY

PART 1 – Progression of the Atomic Model

Use the following information to answer Q1:

Important Advancements in the Atomic Model



Q1: Four important experiments helped to advance the atomic model. For each experiment, assign it to the correct step, numbered ***1*** through ***3*** per the diagram above, where this experiment helped to progress the atomic model.

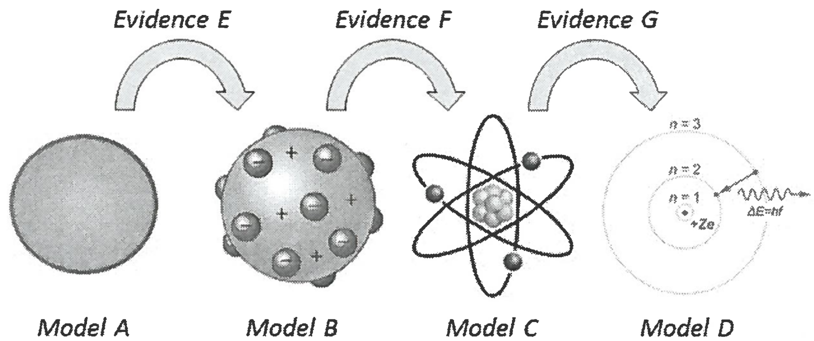
1	3	1	2
Charge to Mass Ratio of Electrons	***Emission Spectrums of Heated Gasses***	***Millikan Experiment***	***Rutherford Scattering***

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

1	3	1	2

KEY

Use the following information to answer Q2:



Common Names	***Credited to***	***Evidence***
1 – Billiard Ball	5 – Bohr	8 – Alpha particle scattering
2 – Bohr	6 – Rutherford	9 – Cathode ray experiments
3 – Planetary	7 – Thomson	0 – Emission Spectrums
4 – Plum Pudding		

Q2: Using the numbers above, who are Model B through Model D ***credited to***?

7	6	5
Model B	***Model C***	***Model D***

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

7	6	5	

Q3: Which model is credited with first acknowledging that the atom is mostly empty space?

a. Bohr
b. Dalton
c. J.J. Thomson
d. Rutherford

Q4: Which model was the first to incorporate the concept of electrons existing in energy levels?

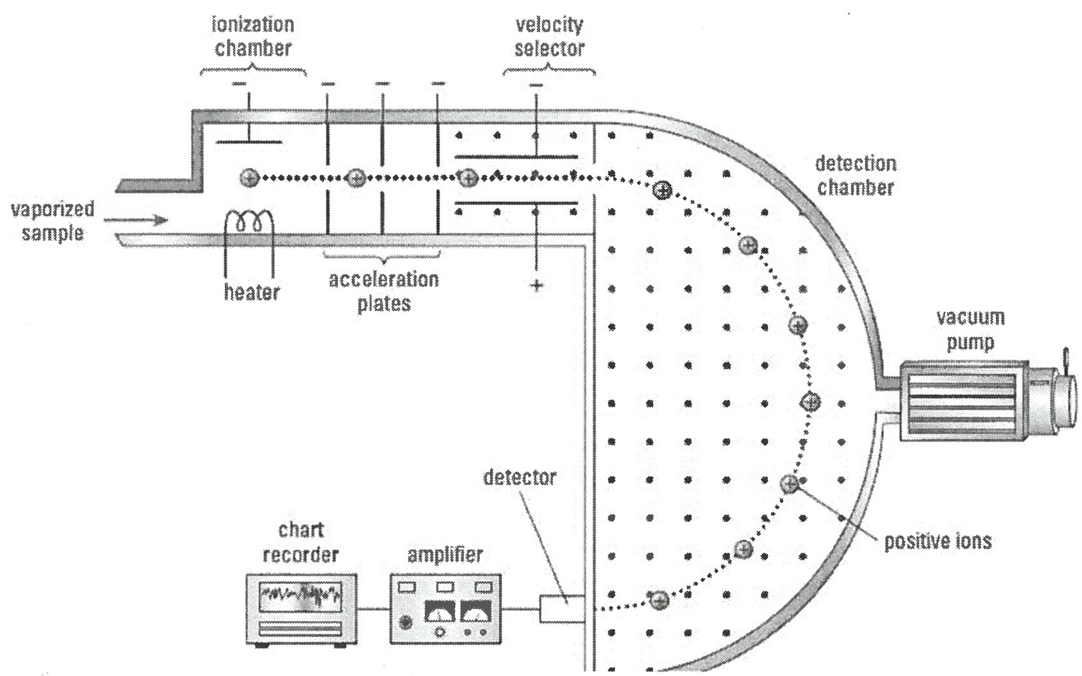
a. Bohr
b. Dalton
c. J.J. Thomson
d. Rutherford

KEY

PART 2 – Mass Spectrometers

Use the following information to answer Q5 –Q7:

Mass Spectrometer



Q5: A subatomic particle makes it through the ***velocity selector*** undeflected. If the magnitude of the electric field is 2.00×10^5 N/C, and the magnetic field is 0.36 T, then the speed of the unknown particle must be ***a.bc*** x 10^{d} m/s, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

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

5	5	6	5

$F_m = F_e$

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

$v = \frac{|\vec{E}|}{|\vec{B}|} = \frac{2.00\times10^5}{0.36} = 5.5\bar{5}\times10^5$

$\approx 5.56 \times 10^5$ m/s

KEY

Q6: In the detection chamber, the particle is again subject to a 0.36 T magnetic field. If the radius of curvature of the particle is 1.61 cm, then the charge to mass ratio must be ***a.bc*** x 10^d C/kg, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

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

9	5	9	7

$$F_m = F_c$$

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

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

$$\frac{q}{m} = \frac{v}{r|\vec{B}|} = \frac{(5.5\times10^5)}{(1.61\times10^{-2})(0.36)}$$

$$\frac{q}{m} = 9.585\ldots\times10^7\ \frac{C}{kg}$$

$$\approx 9.59\times10^7\ C/kg$$

Q7: The unknown particle is most likely

a. An electron
b. A proton
c. An alpha particle *(helium nucleus; $2p^+$, $2n^0$)*
d. A positron *(same mass as an electron, but positive charge)*

Electron $\frac{q}{m} = \frac{1.60\times10^{-19}}{9.11\times10^{-31}} = 1.76\times10^{11}\ \frac{C}{kg}$

Proton $\frac{q}{m} = \frac{1.60\times10^{-19}}{1.67\times10^{-27}} = 9.58\times10^{7}\ C/kg$

Alpha Particle $\frac{q}{m} = \frac{2(1.60\times10^{-19})}{6.65\times10^{-27}} = 4.81\times10^{7}\ C/kg$

Positron $\frac{q}{m} = \frac{1.60\times10^{-19}}{9.11\times10^{-31}} = 1.76\times10^{11}\ C/kg$

KEY

PART 3 – Millikan Experiment

Q8: The Millikan Experiment is credited with proving that

a. cathode rays had mass → Cathode Ray Tube
b. cathode rays were negatively charged → Cathode Ray Tube
c. charge was quantized
d. All electrons have the same charge-to-mass ratio → Mass Spectrometer

Q9: A Millikan-type experiment is conducted, where an oil drop of mass 1.13×10^{-14} kg is suspended in an electric field of 2.30×10^{4} N/C. How many excess electrons does the oil drop have?

a. 4.82×10^{-18} electrons
b. 4.82×10^{-15} electrons
c. 3.00×10^{1} electrons
d. 3.01×10^{4} electrons

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

m

$F_g = mg$

$|\vec{F_e}| = |\vec{F_g}|$

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

$q(2.3\times10^{4}) = (1.13\times10^{-14})(9.81)$

$q = 4.8196\ldots \times 10^{-18}$ C

$q = 30e^-$

So 30 electrons.

Don't care.

Q10: An oil drop with a mass of 7.20×10^{-16} kg moves upward at a constant speed of 2.50 m/s between two horizontal, parallel plates. If the electric field strength between these plates is 2.20×10^{4} V/m, the magnitude of the charge on the oil drop is ***a.b*** $\times 10^{-cd}$ C, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

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

3	2	1	9

Constant speed means no accel, net force.

$|\vec{F_e}| = |\vec{F_g}|$

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

$q(2.20\times10^{4}) = (7.20\times10^{-16})(9.81)$

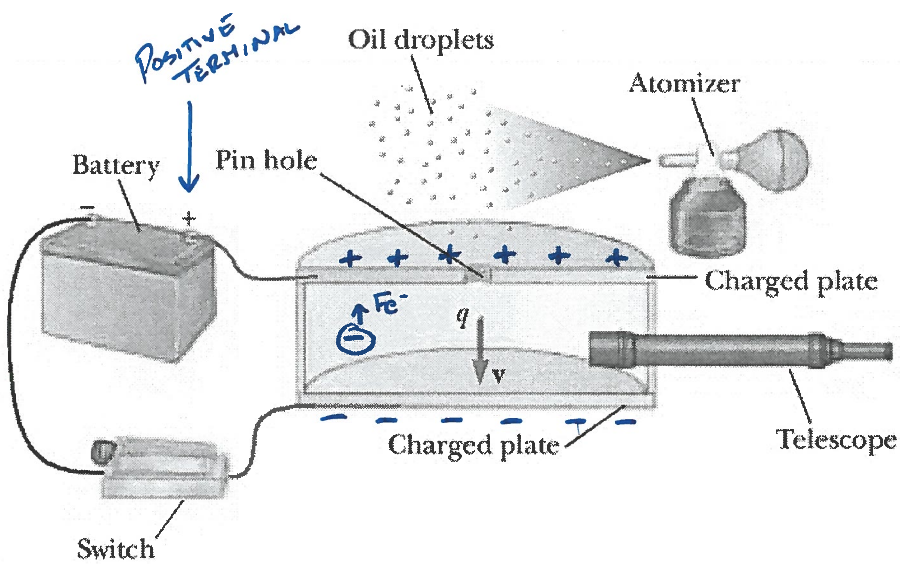
$q = 3.21\times10^{-19}$ C

$\approx 3.2 \times 10^{-19}$ C

■ KEY ■

Use the following information to answer Q11:

Original **Millikan Experiment Apparatus**



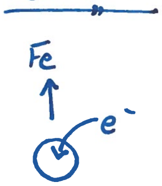
Q11: Using the Millikan Experiment Apparatus above, we can state that the x-rays ionized the __*i*__, causing electrons to attach to the __*ii*__, giving the oil drops a net __*iii*__ charge.

	i	*ii*	*iii*
A.	Air	Oil	Positive
→ **B.**	Air	Oil	Negative
C.	Oil	Air	Positive
D.	Oil	Air	Negative

Which row best completes the above sentence?

a. Row **A.**
b. Row **B.**
c. Row **C.**
d. Row **D.**

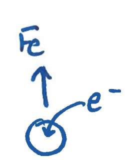
OPTION A



OIL WOULD BE NEGATIVE!

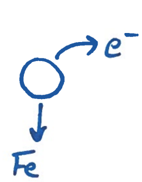
THIS DOESN'T WORK.

OPTION B



THIS ONE WORKS!

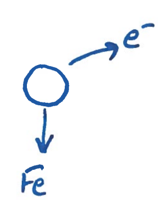
OPTION C



POSITIVE OIL WOULDN'T HOVER.

THIS DOESN'T WORK

OPTION C



OIL WOULD BE POSITIVE

THIS DOESN'T WORK.

[redacted] KEY [redacted]

PART 4 – Emission and Absorption Spectrum

Use the following information to answer Q12-14:

An In-Depth Understanding of Energy Level Diagrams

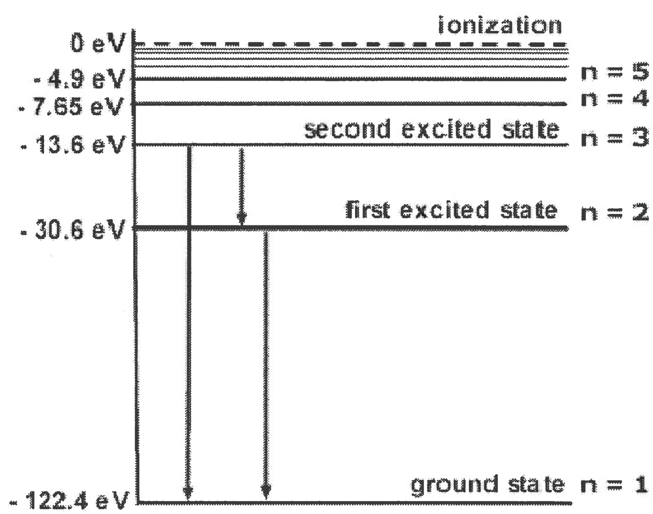
Energy level diagrams are a means of analyzing the energies electrons can accept and release as they transition from one accepted orbital to another. These energies differences correspond to the wavelengths of light in the discreet spectral lines emitted by an atom as it goes through de-excitation or by the wavelengths absorbed in an absorption spectrum.

Using the Bohr Model, the energy levels (in electron volts, eV) are calculated with the formula:

$$E_n = -13.6\ (Z^2/n^2)\ \text{eV}$$

where Z is the atomic number and n is the energy level. The ground state is represented by n = 1, first excited state by n = 2, second excited state by n = 3, etc.

Using Bohr's formula, a hypothetical, doubly-ionized atom[1] with Z = 3 could have the following energy level diagram.



Notice how each energy level closer and closer to the nucleus is more and more negative. This signifies that the electron is trapped in an "energy well." To ionize a ground-state electron (to take it from -122.4 eV to 0 eV in our example), you would have to irradiate the gas with photons having energies of 122.4 eV or greater. This is the ONLY instance where the incident energy does not have to EXACTLY match the different in two energy levels. Any excess energy would remain in the form of the ionized electron's kinetic energy.

[1]Doubly-ionized simply means that it has lost two electrons. So this atom (Z=3; Lithium) has $3p^+$ and $1e^-$.

KEY

Q12: As an electron transitions from the second excited state (n=3) to the ground state (n=1), the wavelength of the photon emitted is ***a.bc*** x 10^{-d} m, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

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

1	1	4	8

$\Delta E = 108.8 eV$

$E = hf = \frac{hc}{\lambda}$

$108.8 eV = \frac{(4.14 \times 10^{-15} eVs)(3 \times 10^{8} m/s)}{\lambda}$

$\lambda = 1.14 \times 10^{-8} m$

$\approx 11.4 nm$

Q13: Is the emitted photon from Q12 visible to the human eye? Explain. No. Human eye can see approximately 400 to 700 nm. This 11.4 nm wavelength is WAY to small for us to see.

Q14: If a single electron existed in the ground state, which frequency of photon would ***not*** transition the electron to an excited state?

Starting point.

a. 2.22×10^{16} Hz
b. 2.51×10^{16} Hz
c. 2.77×10^{16} Hz
d. 2.84×10^{16} Hz

A) 2.22×10^{16} Hz

$E = hf$

$E = 91.908 eV$

Matches Ediff between n=1 and n=2.

B) 2.51×10^{16} Hz

$E = hf$

$E = 103.914 eV$

Doesn't match any $n_1 \rightarrow n_x$ transitions.

C) 2.77×10^{16} Hz

$E = hf$

$E = 114.678 eV$

Matches Ediff between n=1 and n=4.

D) 2.84×10^{16} Hz

$E = hf$

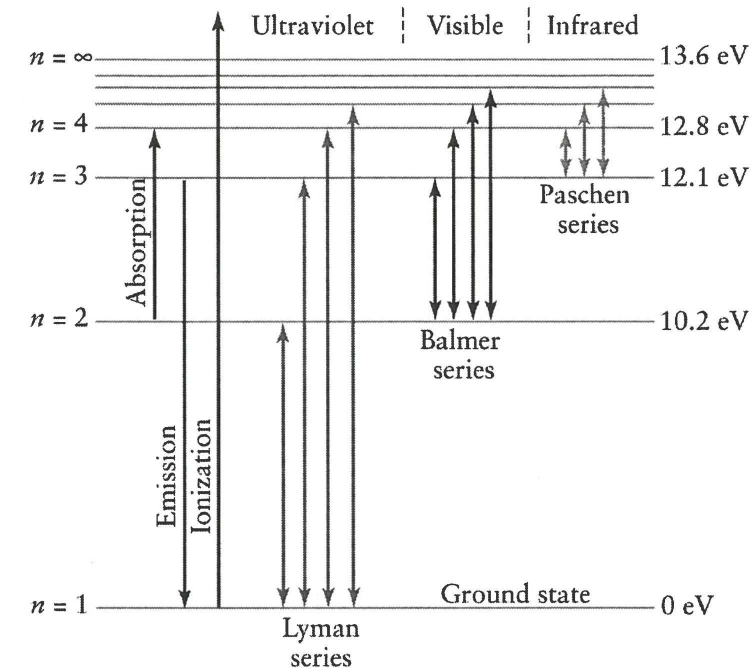
$E = 117.576 eV$

Matches Ediff between n=1 and n=5.

KEY

Use the following information to answer Q15 and Q16:

Hydrogen Atom Energy Level Diagram



Q15: To ionize a hydrogen atom, an electron in the ground state must absorb a photon of

a. E = 13.6 eV
b. E ≤ 13.6 eV
c. E ≥ 13.6 eV → Excess energy goes to kinetic energy of the free electron.
d. E ≠ 13.6 eV

Q16: To bring an electron from the ground state to the first excited state, the electron must absorb a photon of

a. E = 10.2 eV → Must be exact!
b. E ≤ 10.2 eV
c. E ≥ 10.2 eV
d. E ≠ 10.2 eV