[redacted] Atomic Structure [redacted]

Name _____
Team No. _____ **Section** _____

What is an atom?
What is the structure of an atom?

The Model—the structure of an atom

(Reference: sections 2.4 - 2.6 in Silberberg 5th ed.)

The subatomic particles that chemists are typically concerned with are the ***electron***, the ***proton***, and (to a lesser extent) the ***neutron***. The following table shows what distinguishes one subatomic particle from another:

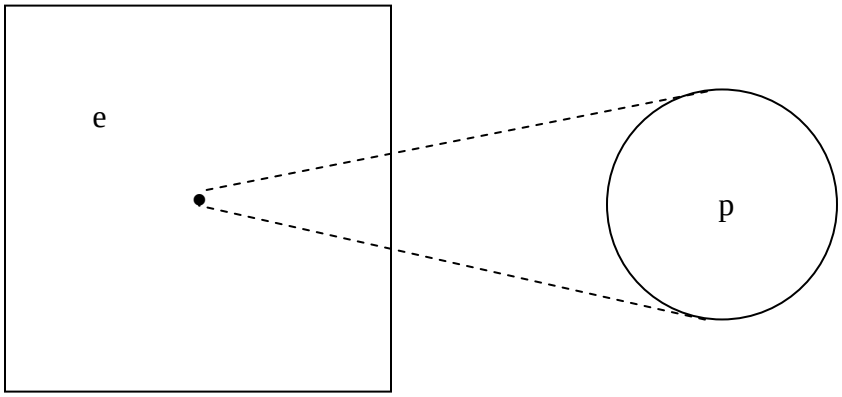
Particle	Charge	Mass (amu*)	Symbol used in the diagrams below
electron	-1	0.00055	e
proton	+1	1.00728	p
neutron	0	1.00867	n

* The ***atomic mass unit*** (amu) is equivalent to 1.6606×10^{-24} g.

Suppose we had a VERY powerful microscope/camera that allowed us to take the following "snapshots" of atoms. (A snapshot is involved because the particles within the ***nucleus of an atom*** (don't confuse it with a nucleus of a cell!) are in constant motion as are the electrons in space outside of the nucleus. To see what's in the nucleus, we have to zoom in real close.

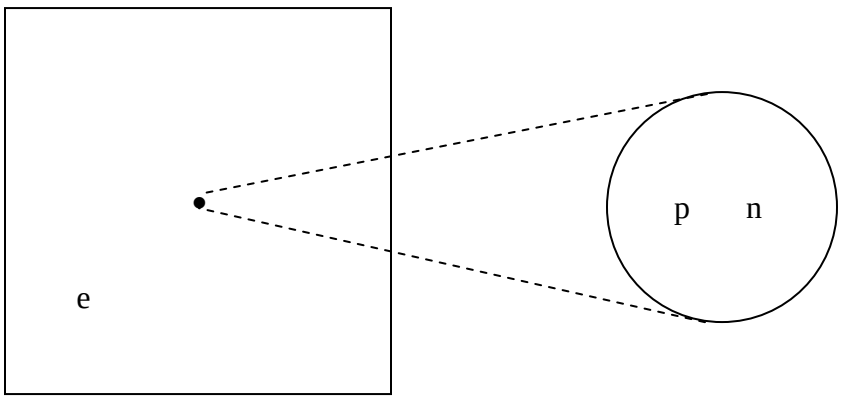
Hydrogen-1

$^{1}_{1}H$



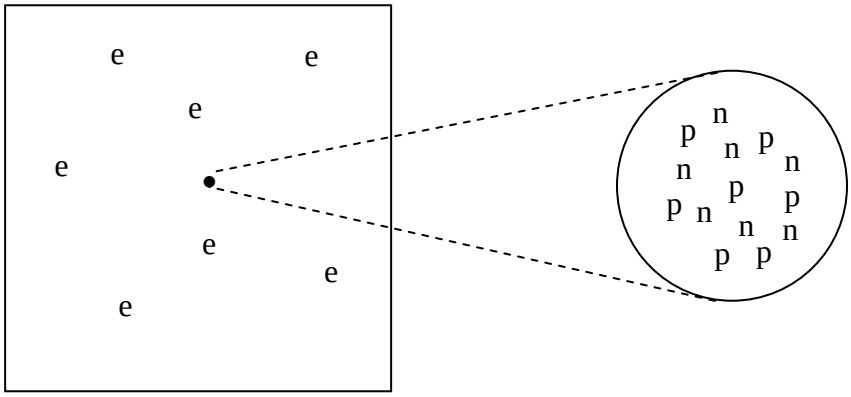
Hydrogen-2

$^{2}_{1}H$



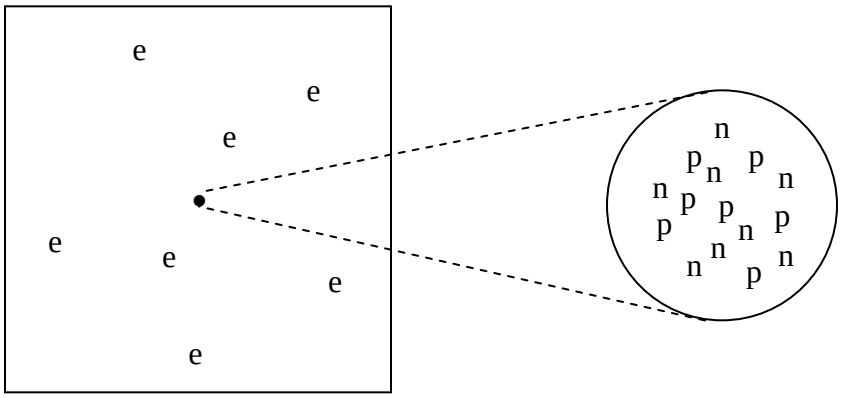
Nitrogen-14

$^{14}_{7}N$



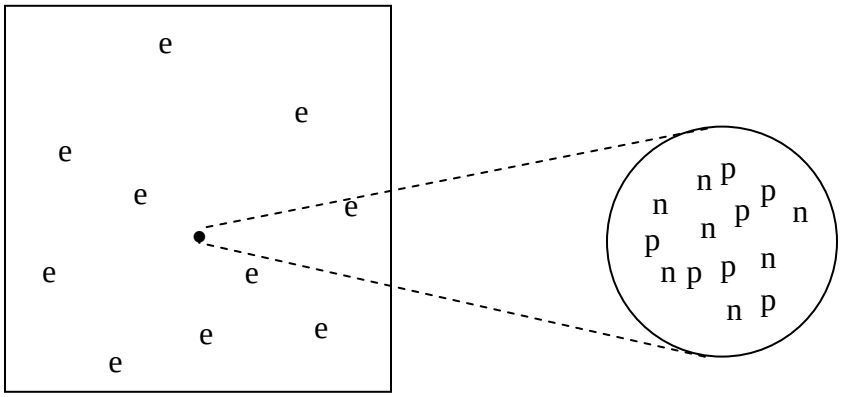
Nitrogen-15

$^{15}_{7}N$



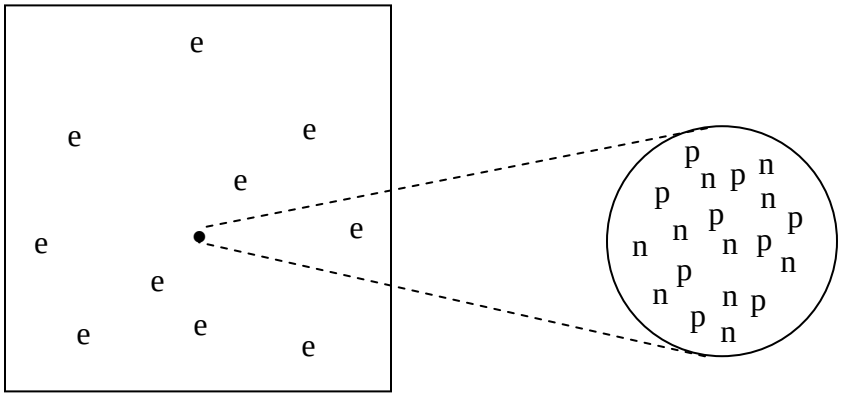
a Nitride ion (an ion of nitrogen)

$^{14}_{7}N^{3-}$



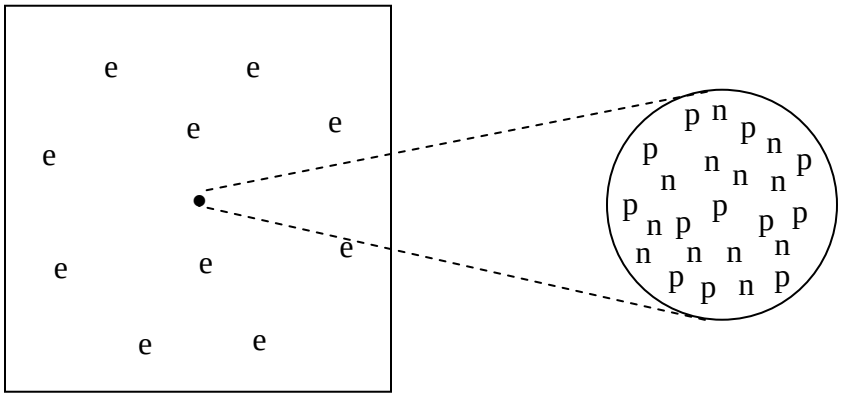
a Fluoride ion (an ion of fluorine)

$^{19}_{9}F^{-}$



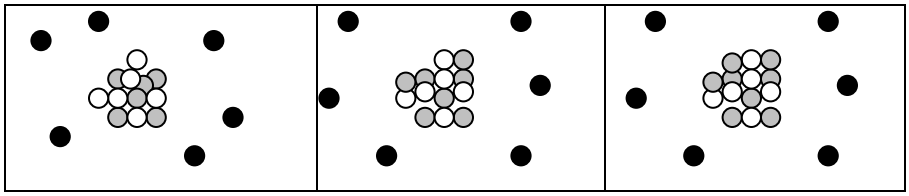
a Magnesium ion

$^{24}_{12}Mg^{2+}$



The following three diagrams are carbon atoms using the following symbols (not drawn to scale)

○ = proton (positive charge) ● = electron (negative charge) ◍ = neutron (no charge)



$^{12}_{6}C$ $^{13}_{6}C$ $^{14}_{6}C$

(6 protons, 6 neutrons) (6 protons, 7 neutrons) (6 protons, 8 neutrons)

Notice the type of notation used for atoms: $^{A}_{Z}X$

X = chemical symbol of the element
Z = "atomic number"
A = "mass number"

$^{12}_{6}C$, $^{13}_{6}C$, and $^{14}_{6}C$ are notations that represent ***isotopes*** of carbon.

$^{1}_{1}H$, $^{2}_{1}H$ and $^{3}_{1}H$ are notations that represent ***isotopes*** of hydrogen.

The part of the atom where the protons and neutrons are is called the ***nucleus***.

Key Questions

1 a.) How many ***protons*** are found in each of the following? $^{14}_{7}N$ _____ $^{15}_{7}N$ _____ $^{14}_{7}N^{3-}$ _____

b.) How many ***neutrons*** are found in each of the following? $^{14}_{7}N$ _____ $^{15}_{7}N$ _____ $^{14}_{7}N^{3-}$ _____

c.) How many ***electrons*** are found in each of the following? $^{14}_{7}N$ _____ $^{15}_{7}N$ _____ $^{14}_{7}N^{3-}$ _____

2 a.) Based on the Model, what do all atoms (neutral or charged) of ***Nitrogen*** have in common?

b.) Based on the Model, what do all atoms (neutral or charged) of ***Hydrogen*** have in common?

3. Look at the ***Periodic Table*** on page 7. What is the significance of the number (called the **atomic number** and represented by the letter *Z*) that appears above the symbol of each element on the periodic table. (*e.g.*, "H" for Hydrogen and "N" for Nitrogen)?

4. What do all ***Arsenic*** (As) atoms have in common?

5. The number of what subatomic particle determines the ***identity of an atom***?

6. The left-hand superscript in the symbol for an atom (*e.g.*, the 2 in ${}^{2}_{1}\mathrm{H}$) is called the ***mass number*** and is represented by the letter **A**. What subatomic particle(s) determine(s) the value of **A**?

7. Hydrogen-1, Hydrogen-2 and Hydrogen-3 are ***isotopes*** of the element Hydrogen. Nitrogen-14 and Nitrogen-15 are isotopes of the element Nitrogen. What subatomic particle distinguishes isotopes of the same element from each other?

8. If present, what does the ***right-hand superscript*** in the symbol for an atom (*e.g.*, the "2+" in ${}^{24}_{12}\mathrm{Mg}^{2+}$) tell the reader?

9 a.) When an atom becomes an ***ion*** (*e.g.*, when ${}^{14}_{7}\mathrm{N}$ becomes ${}^{14}_{7}\mathrm{N}^{3-}$), which subatomic particle undergoes a change in number in the atom?

b.) Is that particle gained or lost? Explain.

c. How is the magnitude of the charge on an ion determined?

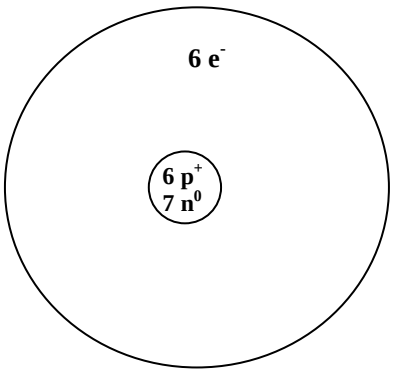
Exercises

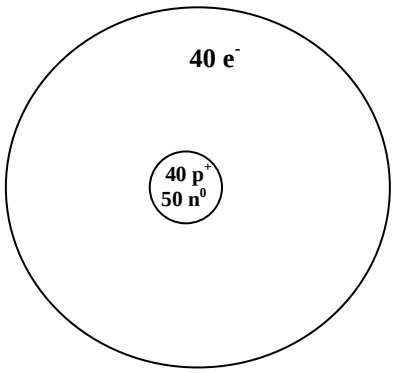
10. Complete the table below.

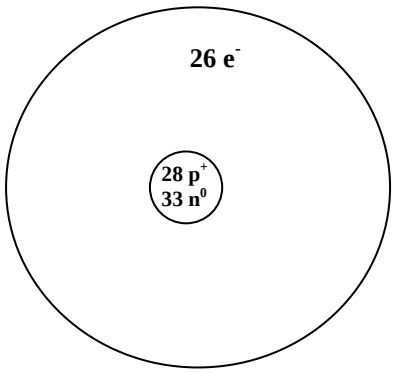
Isotopic Symbol	*Z*	*A*	# of electrons	# of protons	# of neutrons
$^{12}_{6}\mathrm{C}$					
$^{56}_{26}\mathrm{Fe}^{3+}$					
$^{32}_{16}\mathrm{S}^{2-}$					
	42	98	42		
			48	50	70
	15		18		16

11. Write the isotopic notation (e.g. $^{9}_{4}\mathrm{Be}$) for each representation of the following atoms or ions.

a.) Isotopic notation: **b.)** Isotopic notation: **c.)** Isotopic notation:





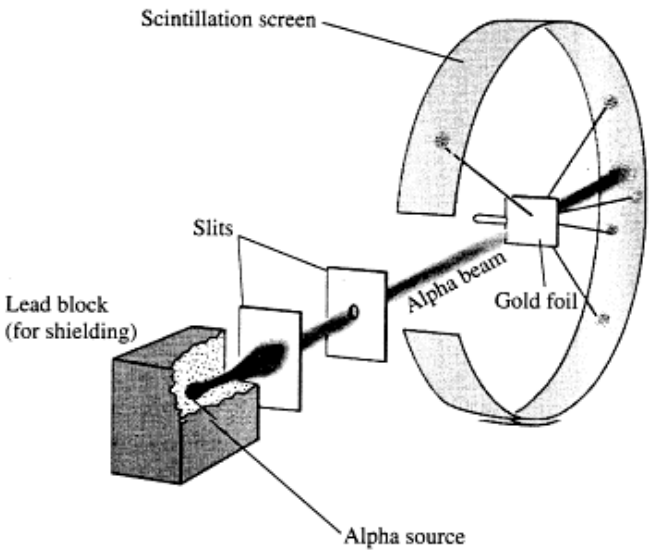


12. Draw the atomic representations similar to those in the previous question for each of the following atoms or ions.

a.) $^{207}_{82}\mathrm{Pb}$ **b.)** $^{9}_{4}\mathrm{Be}$ **c.)** $^{75}_{33}\mathrm{As}^{5+}$

13. Rutherford's "gold foil experiment" involves passing a beam of ***α-particles*** (*i.e. helium nuclei*, He^{2+}) through a very thin sheet of gold. Most of the α-particles pass through the gold foil (a very dense metal) with little or no deflection. However, a few of the α-particles are observed to be deflected significantly—some were even deflected back to the source!

a.) Explain why most of the α-particles pass directly through the gold foil with little to no deflection.



b.) Explain why only a very small fraction of the α-particles have large deflection angles.

c.) Explain why some of the α-particles are deflected back to the source. What does this tell you about the structure of the atom?

14. What is the ***net charge*** on *every* atom? *Explain why*.

15. An oxide ion (oxygen ion) has a 2– charge. (Use your periodic table if necessary)

a.) How many ***protons*** does the oxide ion have?

b.) How many ***electrons*** does an oxide ion have?

PERIODIC TABLE OF THE ELEMENTS

What do all of the elements that are shaded have in common?

	1 A												3 A	4 A	5A	5 A	7 A	8A
1	1 H 1.0079	2A																2 He 4.0026
2	3 Li 6.941	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 16.00	9 F 19.00	10 Ne 20.179
3	11 Na 22.99	12 Mg 24.30	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	13 Al 26.98	14 Si 28.09	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.938	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.1	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.91	54 Xe 131.29
6	55 Cs 132.91	56 Ba 137.33	57 ◈La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra 226.02	89 ✳Ac 227.03	104 Unq (261)	105 Unp (262)	106 Unh (263)	107 Uns (262)	108 Uno (265)	109 Une (266)									

◈ Lanthanides	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
✳ Actinides	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)