Atomic Theory Review

Fill in the Blank

mass number 1. The number of protons and neutrons in the nucleus of an atom is the __.

isotopes 2. Atoms possessing the same number of protons but a different number of neutrons are __.

ground state 3. The lowest energy state of an electron in an atom is the __.

nucleon 4. A particle found in the nucleus is called a(n) __.

atomic number 5. The number of protons in an atom is represented by the __.

protons 6. The identity of an element is determined by the number of __ present.

orbital 7. The volume and shape of the region in space where you would be most likely to locate an electron is a(n) __.

diagonal rule 8. A system for predicting the order of filling energy sublevels with electrons is the __.

orbital 9. The letters s, p, d, or f, are used to designate a particular __ within an energy level.

Multiple Choice

D 1. Of the following assumptions or results of Dalton's atomic theory, the only one that remains essentially correct in most cases is
- A) All atoms of an element are identical in mass.
- B) Atoms are indivisible and indestructible.
- C) Oxygen has an atomic weight of 7.
- D) Atoms of elements combine in the ratios of small whole numbers to form compounds.

A 2. Rutherford's experiments on the scattering of particles by thin metal foils established that
- A) The mass and charge of an atom are concentrated in a nucleus.
- B) Electrons are fundamental particles of all matter.
- C) All electrons have the same charge.
- D) Atoms are electrically neutral.

C 3. The species that has the same number of electrons as $^{32}_{16}S$ is

A) $^{35}_{17}Cl^{-}$ B) $^{34}_{16}S^{+}$ C) $^{40}_{18}Ar^{2+}$ D) $^{35}_{16}S^{2-}$

C 4. All of the following masses are possible for an individual carbon atom except one. That impossible one is
- A) 12.000 00 amu
- B) 13.003 35 amu
- C) 12.011 15 amu
- D) 14.003 24 amu

D 5. There are two principal isotopes of indium (atomic weight = 114.82). One of these, $^{113}_{49}In$, has an atomic mass of 112.9043 amu. The second isotope is most likely to be

A) $^{111}_{49}In$ B) $^{112}_{49}In$ C) $^{114}_{49}In$ D) $^{115}_{49}In$

Short Answer

1. Compare the similarities and differences between Rutherford's and Bohr's theories of the atom.

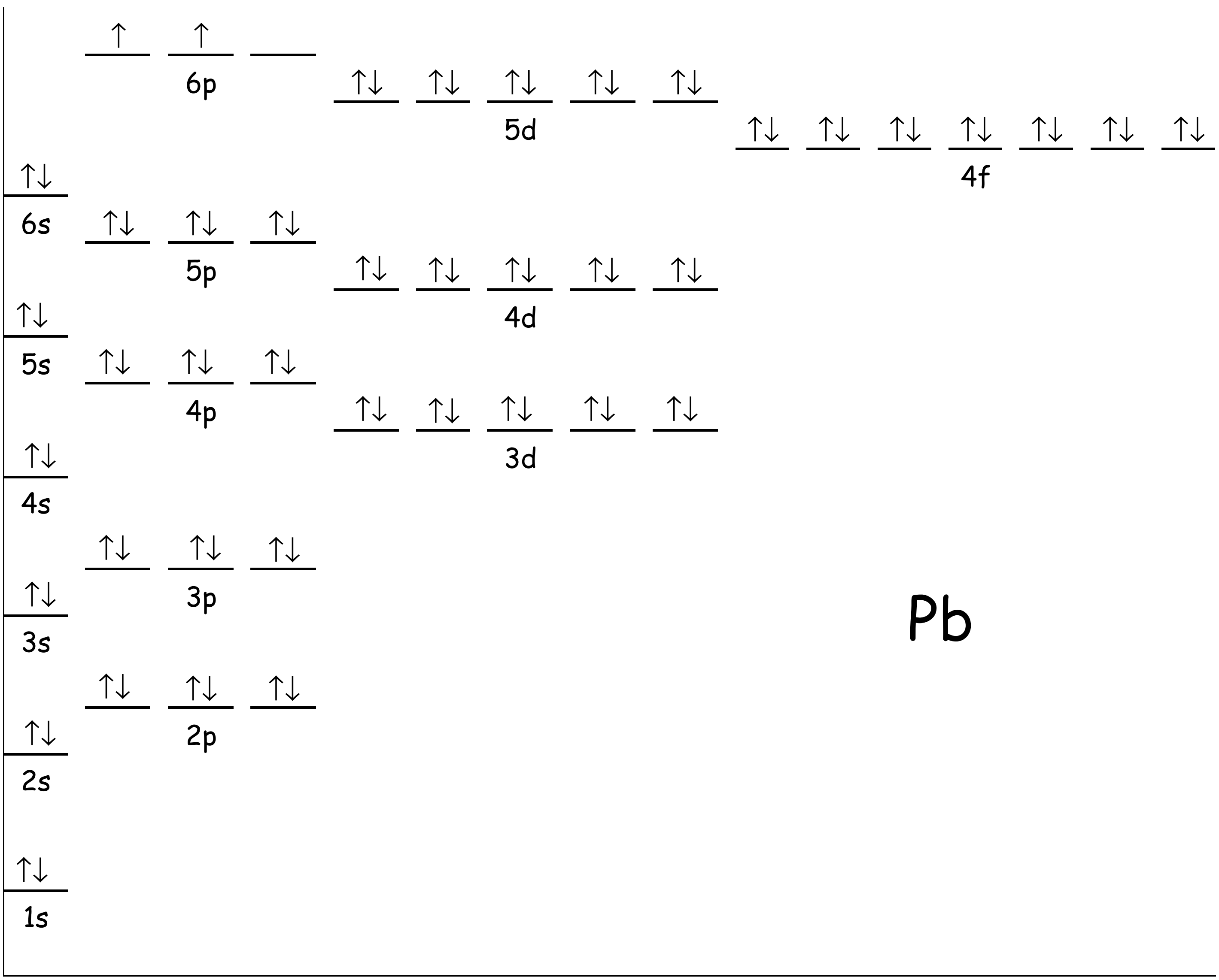
Both Rutherford's and Bohr's models of the atom have a nucleus, which is an extremely small, dense region in the center of the atom, that contains most of the atom's mass and all of its positive charge. Both models have negatively charged electrons orbiting the nucleus. The difference is that Bohr's model specifies the exact path of the electrons. According to Bohr, electrons travel in energy levels. The energy of the electron is quantized – the electron can only exist at specific allowable energy levels. Rutherford's model did not specify the path taken by the electron.

2. Compare the similarities and differences between Bohr's model and the Quantum Mechanical model of the atom.

Both Bohr's model and the Quantum Mechanical model of the atom have a nucleus, which is an extremely small, dense region in the center of the atom that contains most of the atom's mass and all of its positive charge. Both models have electrons whose energy is quantized. Bohr thought that he could describe the exact path taken by an electron, but the Quantum Mechanical model states that we cannot specify the exact path of the electron, only the region where an electron is most likely to be found. This region is called an orbital. Additionally, there is more than one type of orbital.

3. Draw energy level diagrams, and write electron configurations and energy level populations for lead and rutherfordium.

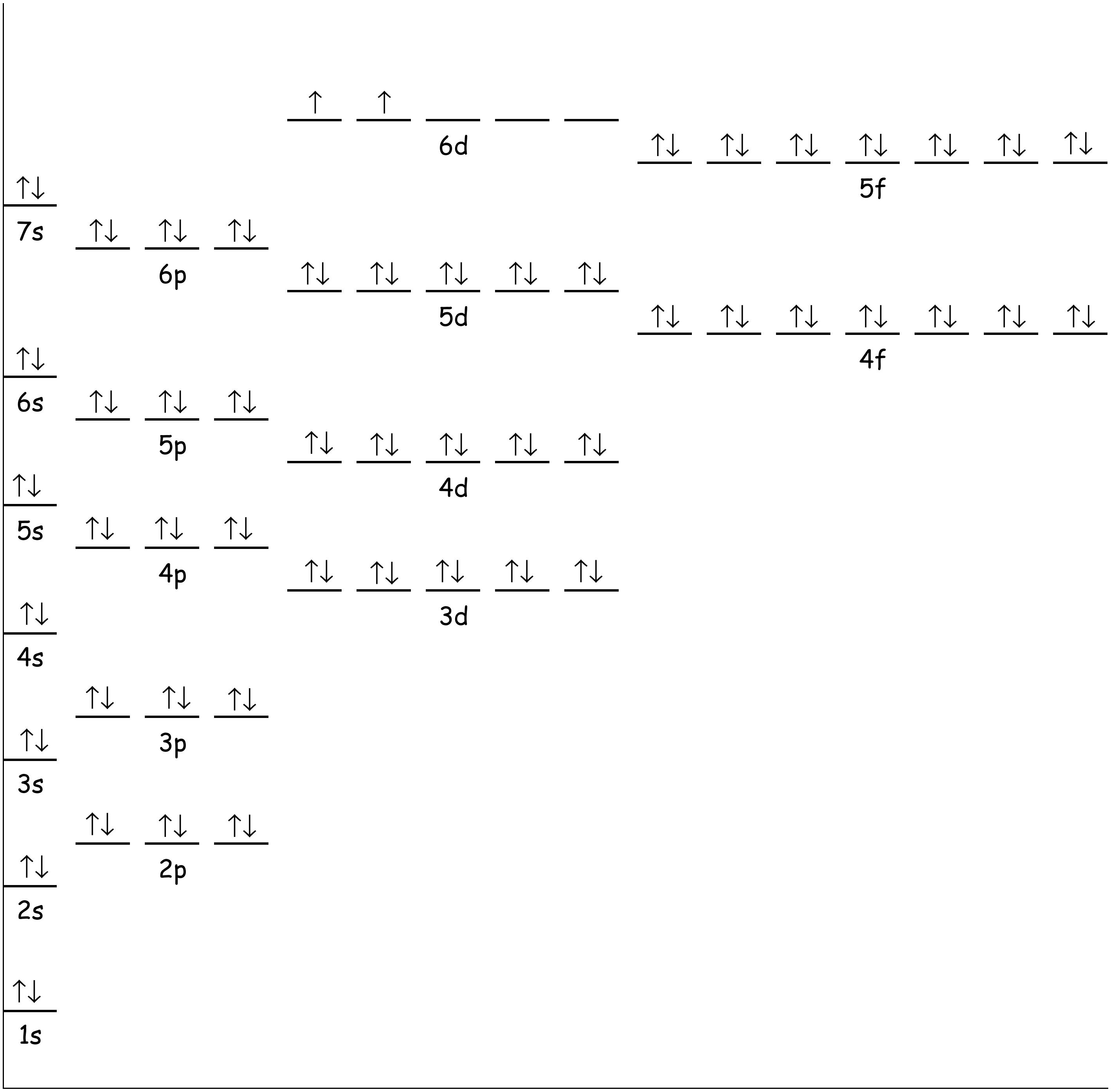
Lead



Electronic Configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^2$

Energy Level Population: 2,8,18,32,18,4

Rutherfordium



Electronic Configuration: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10} 6p^6 7s^2 5f^{14} 6d^2$
Energy Level Population: 2,8,18,32,32,10,2

4. Complete the following table.

Symbol	Atomic Number	Mass Number	Protons	Neutrons	Electrons
${}^{38}_{18}Ar$	**18**	**38**	**18**	**20**	**18**
${}^{18}_{8}O$	**8**	**18**	**8**	**10**	**8**
${}^{36}_{16}S^{2-}$	**16**	**36**	**16**	**20**	**18**
X^{-}	**17**	**37**	**17**	20	18
Mg^{2+}	**12**	26	**12**	14	10

5. Calculate the average atomic mass of nickel that has five naturally occurring isotopes: 67.88% nickel-58 (mass = 57.9353 u), 26.23% nickel 60 (mass = 58.9332 u), 1.19% nickel-61 (mass = 60.9310 u), 3.66% nickel-62 (mass = 61.9283 u), and 1.08% nickel-64 (mass = 63.9280 u).

Mass = (0.6788)(57.9353) + (0.2623)(58.9332) + (0.0119)(60.9310) + (0.0366)(61.9283) + (0.0108)(63.9280)

Mass = 39.33 + 15.46 + 0.725 + 2.27 + 0.6904

Mass = 58.47 u

6. There are two principal isotopes of silver, ${}^{107}_{47}Ag$ and ${}^{109}_{47}Ag$. The atomic weight of naturally occurring silver is 107.87, with 51.82% of the atoms being ${}^{107}_{47}Ag$. The mass of an atom of ${}^{107}_{47}Ag$ is 106.9 amu. What is the mass, in amu, of an atom of ${}^{109}_{47}Ag$?

${}^{107}_{47}Ag$	${}^{109}_{47}Ag$	**Average**
106.9 amu	**x amu**	**107.87 amu**
51.82%	**100% – 51.82% = 48.18%**	

(0.5812)(106.9) + (0.4818)x = 107.87

55.396 + 0.4818x = 107.87

0.4818x = 52.47

x = 108.9

${}^{109}_{47}Ag$ = 108.9 amu

7. Naturally occurring indium consists of two isotopes: indium-113 with an atomic mass of 112.9043 u, and indium-115 with an atomic mass of 114.9041 u. If the average atomic mass of indium is 114.82 u, calculate the percentage of each isotope of naturally occurring indium.

Indium-113	Indium-115	Avg
112.9043 u	114.9041 u	114.82 u
x	y	100%

Equation 1: $112.9043x + 114.9041y = 114.82$

Equation 2: $x + y = 1$

Elimination

Equation 1: $112.9043x + 114.9041y = 114.82$

Equation 2: $-112.9043x - 112.9043y = -112.9043$

$1.9998y = 1.9157$

$y = 0.9579$

$x + y = 1$ $x = 1 - y$ $x = 1 - 0.9579$ $x = 0.0421$

Indium-113 = 4.21%Indium-115 = 95.79%

*8. Naturally, occurring zinc consists of five isotopes, ^{64}Zn, ^{66}Zn, ^{67}Zn, ^{68}Zn, and ^{70}Zn, whose atomic masses are 63.929, 65.926, 66.927, 67.925, and 69.925 amu, respectively. The most abundant isotopes are ^{64}Zn, ^{66}Zn, and ^{68}Zn, which accounts for 48.89%, 27.81%, and 18.57%, respectively, of naturally occurring zinc. Given that the observed atomic mass of zinc is 65.38 amu, calculate the percentages of the two remaining isotopes of zinc.

^{64}Zn	^{66}Zn	^{67}Zn	^{68}Zn	^{70}Zn	Average
63.929 amu	65.926 amu	66.927 amu	67.925 amu	69.925 amu	65.38 amu
48.89%	27.81%	x %	18.57%	y %	

Eqn 1 $(63.929)(0.4889) + (65.926)(0.2781) + (66.927)x + (67.925)(0.1857) + (69.925)y = 65.38$

$$31.255 + 18.334 + 66.927x + 12.614 + 69.925y = 65.38$$

$$62.203 + 66.927x + 69.925y = 65.38$$

$$66.927x + 69.925y = 3.177$$

Eqn 2 $0.4889 + 0.2781 + x + 0.1857 + y = 1$

$$0.9527 + x + y = 1$$

$$x + y = 0.0473$$

Elimination

Eqn 1 $66.927x + 69.925y = 3.177$

(-66.927)(Eqn 2) $\underline{-66.927x - 66.927y = -3.166}$

$2.998y = 0.01177$

$y = 0.00393$

$x = 0.0473 - y$

$x = 0.0473 - 0.00393 = 0.0434$

$^{67}Zn = 4.34\%$ and $^{70}Zn = 0.393\%$

*9. Give all possible sets of quantum numbers for an electron in a 4f orbital.

n	*l*	*m*	*s*
4	**3**	**-3**	$-\frac{1}{2}$
4	**3**	**-3**	$\frac{1}{2}$
4	**3**	**-2**	$-\frac{1}{2}$
4	**3**	**-2**	$\frac{1}{2}$
4	**3**	**-1**	$-\frac{1}{2}$
4	**3**	**-1**	$\frac{1}{2}$
4	**3**	**0**	$-\frac{1}{2}$
4	**3**	**0**	$\frac{1}{2}$
4	**3**	**1**	$-\frac{1}{2}$
4	**3**	**1**	$\frac{1}{2}$
4	**3**	**2**	$-\frac{1}{2}$
4	**3**	**2**	$\frac{1}{2}$
4	**3**	**3**	$-\frac{1}{2}$
4	**2**	**3**	$\frac{1}{2}$