Answers to Composition of Atoms: The Sub-atomic Particles

1. Write complete definitions for each of the following terms. Include one additional piece of information such as an example or application:

a) **Atomic number:** the number of protons in the nucleus of an atom. This determines what type of atom (element) it is. The symbol for atomic number is Z.

b) **Mass number:** this is the sum of the number of protons and the number of neutrons in the nucleus of an atom. This determines how much the atom weighs. Mass number is a counted value, it has no units. The symbol for mass number is A.

c) **Isotope:** Isotopes are atoms of the same element that have different numbers of neutrons, so some atoms of an element are heavier than others. That is, isotopes have the same atomic number but different mass numbers. All isotopes of an element have the same chemical properties. Isotopes are identified using a standard format such as "Zn – 65", where 65 is the mass number of the isotope.

d) **Ion:** an ion is a charged atom. It is charged because the number of electrons does not equal the number of protons. If there are more electrons than protons, the ion will have a negative charge. If there are fewer electrons than protons, the ion will have a positive charge.

2. Complete the following chart:

Element	Atomic #	# of Protons	# of Electrons	Overall Charge	# of Neutrons	Mass Number
He	2	2	2	0	2	4
Al	13	13	10	+3	14	27
Ca	20	20	18	+2	20	40
Ni – 58	28	28	26	+2	30	58
Sr	38	38	36	+2	52	90
V	23	23	23	0	28	51
Ag – 107	47	47	46	+1	60	107
I	53	53	54	-1	74	127
Yb	70	70	67	+3	103	173
Au	79	79	79	0	118	197
Au	79	79	76	+3	118	197
U	92	92	92	0	143	235
U	92	92	92	0	146	238
H – 1	1	1	0	+1	0	1
Ni	28	28	25	+3	31	59
P	15	15	18	-3	16	31
Zn - 65	30	30	28	+2	35	65
Si - 28	14	14	18	-4	14	28

3. Do **ALL** atoms (or ions) contain protons?
   - all atoms **must** contain protons (or they wouldn't be atoms)
   - all atoms **do not** contain electrons eg. the hydrogen ion (H+) has no electron, and an alpha particle (He^{2+}) is a helium nucleus without any electrons
   - all atoms **do not** contain neutrons eg. most hydrogen atoms (H-1) do not have neutrons

4. Using the standard format (eg. "Ag-107"), identify any isotopes from the above table:
   - Ni – 58 and Ni – 59 are isotopes (they are also two different ions of nickel)
   - U – 235 and U – 238 are isotopes of uranium
   - the atoms of gold (Au) are NOT isotopes, because both atoms have the same mass number

Answers to Isotopes and Average Atomic Mass

Question from Unit Outline:

Give three differences between mass number and average atomic mass:

Mass Number	Average Atomic Mass (aka Relative Atomic Mass)
• is the number of protons + neutrons in the nucleus of an atom	• is the weighted average mass of all of the isotopes of an element (the mass is of the whole atom, not just the nucleus so it includes the mass of electrons)
• is a counted value	• is a measured value
• it has no units	• has the units amu or u
• it is not reported on the Periodic Table	• it is reported on the Periodic Table

Questions from page 29 of text:

2. the two particles which are responsible for most of the mass of an atom are the protons and neutrons

4. if an atom has 14 protons and 13 neutrons, its mass number is 27

5. if an atom has 15 protons and a mass number of 31:
   a) its atomic number is 15
   b) it has 16 neutrons (31 – 15 = 16)
   c) the element is phosphorus (atomic number 15)

6. an atom of Cl – 37 has 20 neutrons in its nucleus. The "37" is the mass number of the atom and chlorine has atomic number 17, so 37 – 17 = 20.

Questions from Handout:

2. a) What are ***isotopes***?

   Isotopes are atoms of the same element that have different numbers of neutrons. That is, isotopes are atoms that have the same atomic number (same number of protons) but different mass numbers (different numbers of neutrons).

   b) Gold has four isotopes. Their mass numbers are 195, 196, 198 and 199. Find the number of protons, electrons and neutrons in **neutral** atoms of these isotopes.

Isotope	Number of Protons	Number of electrons	Number of Neutrons
Au – 195	79	79 (neutral)	195 – 79 = 116 neutrons
Au – 196	79	79 (neutral)	196 – 79 = 117 neutrons
Au – 198	79	79 (neutral)	198 – 79 = 119 neutrons
Au – 199	79	79 (neutral)	199 – 79 = 120 neutrons

3. a) What information is given by each part of the expression $^{35}_{17}\mathrm{Cl}$?
   - the Cl is the symbol for the atom chlorine
   - the "17" is the atomic number of chlorine which tells us it has 17 protons in the nucleus
   - the "35" is the mass number which tells us the number of protons + neutrons in the nucleus

   b) We identify isotopes with symbols such as "U-238". What does the number "238" represent?
   "238" is the mass number of that particular isotope of uranium.

Answers to Nuclear Chemistry: Radioisotopes and Types of Nuclear Radiation

Homework: Questions 9, 10, 12 and 13 on page 32 of your text.
Read pages 34 and 35. Answer Q 20, 21 and 22 on page 35.

Questions from page 32 of your text:

9. Distinguish between an isotope and a radioisotope.
   - Isotopes are atoms of an element that have different numbers of neutrons. They may or may not be radioisotopes.
   - Radioisotopes are atoms have an unstable nucleus because they do not have enough, or have too many, neutrons in the nucleus. The nucleus of most atoms contain both protons and neutrons. Protons are positively charged, so they repel each other. Neutrons act like spacers in the nucleus to separate the protons. The right number of neutrons are needed in between the protons to keep the nucleus from breaking apart. If an atom is a radioisotope, it has an unstable nucleus that eventually will break apart to release protons, neutrons and/or energy as it achieves a more stable arrangement.

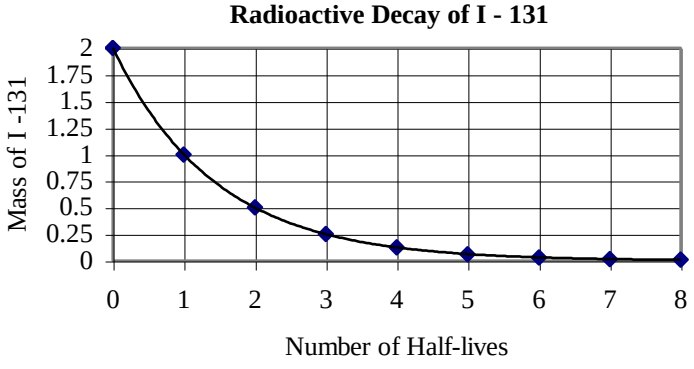
10. Complete the chart:

	Alpha Particle	**Beta Particle**
a) another name for this particle	aka a helium nucleus	aka a high speed electron
b) the symbol for this particle	symbols: α or $^{4}_{2}He$	symbols: β or e^{-} or $^{0}_{1}e$
c) how the nucleus of a radioisotope is altered by emission of this particle	when an alpha particle is emitted, the nucleus will lose 2 protons and 2 neutrons, so the atomic number will go down by 2 and the mass number will go down by 4	when a beta particle is emitted, a neutron is converted to a proton and an electron, so the atomic number will increase by one and the mass number will stay the same
d) the penetrating ability of this type of radiation	does not penetrate matter so it can be stopped by a piece of paper	penetrates somewhat into matter so it can be stopped by a piece of metal 1 – 2 mm thick

12. Radon – 222 has a half-life of 4.0 d. If the initial mass of the sample of this isotope is 6.8 g, calculate the mass of Rn – 222 after:
    a) 8.0 d. This is 2 half-lives, so the 6.8 g is divided in half and then in half again. After 8.0 d there will be 1.7 g of Rn – 222 remaining.
    b) 16.0 d. This is 4 half-lives, so the 6.8 g is divided in half 4 times. After 16.0 d there are 0.425 g of Rn –222 remaining (the answer in the text is wrong).
    c) 32.0 d. This is 8 half-lives, so the 6.8 g is divided half 8 times. After 32.0 d there are 0.02656 g of Rn – 222 remaining (which would round to 0.027 g).

13. Graph of radioactive decay of I – 131:

    Each half life if 8.0 days, so you could also put "Time (d)" on the x – axis and go from 0 to 64 days. The graph will have the same shape.



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Questions from page 35 of your text:

You must read and answer these questions on your own. Know this material for quizzes and unit tests.