2.12 Example Problems

1. Atomic Structure Problems

1. What is the difference between a gram and an atomic mass unit (a.k.a. a Dalton)?

2. What makes all barium (Ba) atoms different from all atoms of any other element?

3. Isotopes always have different densities. Why is this?

4. Write the nuclide symbol for the following particles:

    a) a copper atom with 35 neutrons and 27 electrons

    b) a sulfur atom with 15 neutrons and 17 electrons

5. What is the weighted average mass of potassium if the three major isotopes are K-39 with a mass of 38.96371 amu and an abundance of 93.1%; K-40 with a mass of 39.974 amu and an abundance of 0.00118%; K-41 with a mass of 40.96184 and an abundance of 6.88%?

Exercise 1

Answers to Q 1-5

Answer

1. A gram is a mass unit useful for the macroscopic scale. An amu is a mass unit appropriate for the atomic scale because 1.0000 amu is 1.6605 x 10^{-24} grams.

2. All barium atoms have 56 protons, and all atoms with 56 protons are barium atoms.

3. Isotopes differ by the number of neutrons. the neutrons exist in the nucleus of an atom, and changing the size of the nucleus does not change the size of the atom. Thus isotopes have different masses, but their volumes are the same, meaning they have different densities.

4. a) ${}^{64}_{29}Cu^{2+}$ b) ${}^{31}_{16}S^{1-}$

5. (38.96371)(.931) + (39.974)(0.0000118) + (40.96184)(0.0688) = 39.09 amu

2. The Mole

6. How many moles of sodium atoms (Na) are there in 43.6 grams of sodium atoms?

7. How many grams of argon (Ar) are there in 134 grams of argon atoms?

8. What is the mass, in grams, of 0.675 moles of radium (Ra) atoms?

9. What is the mass, in grams, of 9.64 x 10^{23} osmium (Os) atoms?

Exercise 2

Answers to Q 6-9

Answer

6. $43.6\ grams\ Na\ atoms x \frac{1\ mole\ Na\ atoms}{22.99\ grams\ Na\ atoms}$ = 1.90 grams Na atoms

7. $134\ grams\ Ar\ atoms x \frac{1\ mole\ Ar\ atoms}{39.85\ grams\ Ar\ atoms} x \frac{6.022x10^{23}\ Ar\ atoms}{1\ mole\ Ar\ atoms}$ = 2.02x10^{24} Ar atoms

8. $0.675\ moles\ Ra\ atoms x \frac{226\ grams\ Ra\ atoms}{1\ mole\ Ra\ atoms}$ = 153 grams Ra atoms

9. $9.64x10^{23}\ Os\ atoms x \frac{1\ mole\ Os\ atoms}{6.022x10^{23}\ Os\ atoms} x \frac{190.23\ grams\ Os\ atoms}{1\ mole\ Os\ atoms}$ = 305 grams Os atoms.

3. Nuclear Reactions

10. Determine the nuclide symbol for the missing particle in the following nuclear reactions:

a) $^{35}_{16}S + ^{4}_{2}He \rightarrow ^{18}_{9}F + ?$

b) $^{139}_{56}Ba \rightarrow ^{0}_{-1}\beta + ?$

c) $^{90}_{38}Sr + ^{182}_{75}Re \rightarrow 2^{1}_{0}n + ?$

11. If you start with 25.00 grams of a radioactive nuclide, X, how many grams of X will remain after 3 half-lives?

12. If you start with 37.3 grams of radioactive nuclide X, how many hours will it take until there are only 10.0 grams of X? The half-life of X is 17.1 hours.

Exercise 3

Answers to Q 10-12

Answer

10. a) $^{21}_{9}F$ b) $^{139}_{57}La$ c) $^{270}_{113}Nh$

11. 25.00 → 12.50 → 6.250 → 3.125 g or $(1/2)^3$(25.00 grams) = 3.125 grams

12. $10.0g = (1/2)^n(37.3g) \Rightarrow \dfrac{10.0}{37.3} = (1/2)^n \Rightarrow \dfrac{log(0.2681)}{log(0.5)}$ = n = 1.899 half-lives. 1.899 x 17.1 hours = 32.5 hours.

4. Electronic Structure

13. Which has the greater energy per photon, green light or red light?

14. What does an atomic orbital boundary surface tell you?

15. Tell the maximum number of electrons possible in:

a) a 1s orbital

b) a 5d orbital

c) a 2p subshell

d) a 4d subshell

e) shell 3

16. Compare a Ca atom and an Se atom in terms of

a) atomic size

b) ionization energy

c) electronegativity

d) number of valence electrons

Exercise 4

Answers to Q 13-16

Answer

13. Energy is directly proportional to the frequency, and green light has a higher frequency than red light, so green photons have higher energy than red photons.

14. An atomic orbital boundary surface tells the volume of space in which an electron can be found 90% of the time.

15. a) 2 b) 2 c) 6 d) 10 e) 18

16. A Ca atom a) is larger than a Se atom b) has a lower first I.E. than a Se atom c) has a lower EN than a Se atom d) has fewer valence electrons than a Se atom.

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