Solution to FMS Homework 4, SS 2017

Checklist before you start this homework. (The boxes are clickable.)

☒ I have read the atomic structure related portion (p.18-26) of the chapter.

☒ I have worked on the Example Problems and Concept Check questions.

Homework Problems:

1. Calculate the number of atoms contained in a cylinder 1 μm in diameter by 1 μm deep of **(a)** magnesium and **(b)** lead.

Solution:

From HW3-1, we know

$N_{sample} = 6.64 \times 10^{10}$ atoms

(a)

$$N_{Mg\ atoms} = 6.64 \times 10^{10} \text{ atoms Cu} \times \frac{(1.74\ g/cm^3)\ Mg}{(8.93\ g/cm^3)\ Cu} \times \frac{63.55\ g\ Cu / N_{AV}\ \text{atoms Cu}}{24.31\ g\ Mg / N_{AV}\ \text{atoms Mg}}$$

$$= \underline{3.38 \times 10^{10}} \text{ atoms Mg}$$

(b)

$$N_{Pb}\ \text{atoms} = 6.64\times10^{10}\ \text{atoms Cu} \times \frac{(11.34\ g/cm^3)\ Pb}{(8.93\ g/cm^3)\ Cu}$$

$$\times \frac{63.55\ g\ Cu / N_{AV}\ \text{atoms Cu}}{207.2\ g\ Mg / N_{AV}\ \text{atoms Pb}}$$

$$= 2.59\times10^{10}\ \text{atoms Pb}$$

2. Using the density of MgO calculated in Problem 2 of Homework 3, calculate the mass of an MgO refractory (temperature-resistant) brick with dimensions 50 mm X 100 mm X 200 mm.

Solution:

From HW3-2, $\rho = 3.60\ g/cm^3$

$$m = \rho V = (3.60\ g/cm^3)(10^{-3}\ cm^3/mm^3)$$

$$\times (50)(100)(200)\ mm^3$$

$$= 3.60\times10^3\ g = 3.60\ kg$$

3. Calculate the dimensions of **(a)** a cube containing 1 mol of copper and **(b)** a cube containing 1 mol of lead.

Solution:

(a) $\text{edge} = \left(\frac{63.55 \text{ g/mol}}{8.93 \text{ g/mol}}\right)^{1/3} \times 10 \text{ mm/cm} = \underline{19.23 \text{ mm}}$

(b) $\text{edge} = \left(\frac{207.2 \text{ g/mol}}{11.34 \text{ g/mol}}\right)^{1/3} \times 10 \text{ mm/cm} = \underline{26.34 \text{ mm}}$

4. Silicon has three naturally-occurring isotopes: 92.23% of ^{28}Si, with an atomic weight of 27.9769 amu, 4.68% of ^{29}Si, with an atomic weight of 28.9765 amu, 3.09% of ^{30}Si, with an atomic weight of 29.9738 amu. On the basis of these data, confirm that the average atomic weight of Si is 28.0854 amu.

Solution:

The average atomic weight of Si $(\bar{A}_{Si})$ is computed by adding fraction-of-occurance/atomic weight products for the three istopes.

$$\bar{A}_{Si} = f_{^{28}Si} A_{^{28}Si} + f_{^{29}Si} A_{^{29}Si} + f_{^{30}Si} A_{^{30}Si}$$

$$= (0.9223)(27.9769) + (0.0468)(28.9765) + (0.0309)(29.9738) = \underline{28.0854}$$

5. Allowed values for quantum numbers of electrons are as follows:

n=1, 2, 3, …

l=0, 1, 2, 3, …, n-1

m_l=0,±1,±2,±3, … ,±l

$m_s=\pm\frac{1}{2}$

The relationship between n and the shell designation are noted in Table 2.1. Relative to the subshells,

l=0 corresponds to an *s* subshell

l=1 corresponds to a *p* subshell

l=2 corresponds to a *d* subshell

l=3 corresponds to an *f* subshell

For the *K* shell, the four quantum numbers for each of the two electrons in the 1s state, in the order of nlm_lm_s, are 100($\frac{1}{2}$) and 100(-$\frac{1}{2}$).

Write the four quantum numbers for all of the electrons in the *L* and *M* shells, and note which correspond to the *s*, *p*, and *d* subshells.

Solution:

For the L state, n=2, 8 electon states

l: 0, 1

Ml: 0, ±1

ms: $\pm\frac{1}{2}$

So, for the s state: 200($\frac{1}{2}$), 200($-\frac{1}{2}$)

for the p state: 210($\frac{1}{2}$), 210($-\frac{1}{2}$), 211($\frac{1}{2}$), 211($-\frac{1}{2}$), 21(-1)($\frac{1}{2}$), 21(-1)($-\frac{1}{2}$)

For the M state, n=3, 18 electon states

l: 0, 1, 2

Ml: 0, ±1, ±2

ms: $\pm\frac{1}{2}$

So, for the s state: $3 0 0 (\frac{1}{2})$, $3 0 0 (-\frac{1}{2})$

for the p state: $3 1 0 (\frac{1}{2})$, $3 1 0 (-\frac{1}{2})$,

$3 1 1 (\frac{1}{2})$, $3 1 1 (-\frac{1}{2})$, $3 1 (-1) (\frac{1}{2})$, $3 1 (-1) (-\frac{1}{2})$

for the d state: $3 2 0 (\frac{1}{2})$, $3 2 0 (-\frac{1}{2})$, $3 2 1 (\frac{1}{2})$

$3 2 1 (-\frac{1}{2})$, $3 2 (-1) (\frac{1}{2})$, $3 2 (-1) (-\frac{1}{2})$, $3 2 2 (\frac{1}{2})$,

$3 2 2 (-\frac{1}{2})$, $3 2 (-2) (\frac{1}{2})$, $3 2 (-2) (-\frac{1}{2})$

6. Give the electron configurations for the subshells of the following ions: Fe^{2+}, Fe^{3+}, Cu^{+}, Ba^{2+}, Br^{-}, and S^{2-}.

Solution:

Fe^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

Fe^{3+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$

Cu^{+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$

Ba^{2+}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$
$4d^{10} 5s^2 5p^6$

Br^{-}: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$

S^{2-}: $1s^2 2s^2 2p^6 3s^2 3p^6$