WORKSHEET-SOLIDS

Set A:

1. Indicate the **type of crystalline** solid each of the following would form upon crystallization. Tell what **type of particles** are located at the lattice points and the **types of attractive forces** that exist between the particles.

	Type of crystalline solid	Type of particles at lattice points	Attractive forces between lattice points
SiC	Network covalent	Atoms	Covalent bonds
HBr	Molecular	Molecules	IMF: Dipole-Dipole
Cu	Metallic	metal cations	Attraction between cations and sea of e-
Br_2	Molecular	Molecules	IMF: Dispersion
$NH4ClO_3$	Ionic	cations & Anions	Electrostatic Attraction

2. Crystalline aluminum has cubic structure. The unit edge length is 4.440×10^{-8}. The density of solid aluminum is 4.096 g/cm^3. Calculate the number of aluminum atoms in one unit cell.

Answer=8.00 atoms/unit cell

$$\text{Vol unitcell} = a^3 = (4.440 \times 10^{-8}\ \text{cm})^3 = 8.750 \times 10^{-23}\ \text{cm}^3$$

$$\text{mass of all atoms inside unitcell} = 4.096\ \frac{\text{g}}{\text{cm}^3} \times 8.750 \times 10^{-23}\ \text{cm}^3 = \frac{3.585 \times 10^{-22}\ \text{g Al}}{\text{uc}}$$

$$3.585 \times 10^{-22}\ \frac{\text{g Al}}{\text{uc}} \times \frac{1\ \text{mol Al}}{27.0\ \text{g}} \times \frac{6.02 \times 10^{23}\ \text{atoms Al}}{1\ \text{mol}} = \frac{8\ \text{atom}}{\text{uc}}$$

3. The volume of a manganese **atom** is 9.21×10^{-24} cm^3. Manganese crystallizes in a face-centered cubic system. What is the density of manganese? Answer: 7.34 g/cm^3

Setup:

1. $\text{Vol atom} = \frac{4}{3}\pi r^3$

$$9.21 \times 10^{-24}\ \text{cm}^3 = \frac{4}{3}\pi r^3$$

$$r = 1.30 \times 10^{-8}\ \text{cm}$$

2. $f = 4r$ & $a = \frac{f}{\sqrt{2}}$

$$a = \frac{4r}{\sqrt{2}} = \frac{4(1.30 \times 10^{-8}\ \text{cm})}{\sqrt{2}} = 3.677 \times 10^{-8}\ \text{cm}$$

3. $\frac{54.94\ \text{g Mn}}{\text{mole Mn}} \times \frac{1\ \text{mol Mn}}{6.02 \times 10^{23}\ \text{atoms}} \times \frac{4\ \text{atoms}}{\text{uc}} = \frac{3.65 \times 10^{-22}\ \text{g Mn}}{\text{uc}}$

4. $D = \frac{3.65 \times 10^{-22}\ \text{g Mn}}{\text{uc}} \times \frac{1\ \text{uc}}{(3.677 \times 10^{-8}\ \text{cm})^3} = 7.34\ \text{g}$

Set B:

1. $CaCl_2$ (s) crystallizes in a cubic lattice. The unit cell has an edge of 4.77×10^{-8} cm. The density of $CaCl_2$ (s) is 6.80 g/cm^3. How many formula units of $CaCl_2$ must there be per unit cell?

Answer: 4 formula units

g of $CaCl_2$ per uc

$$\frac{6.80\ g\ CaCl_2}{cm^3} \times \frac{(4.77 \times 10^{-8}\ cm)^3}{uc} = \frac{7.38 \times 10^{-22}\ g\ CaCl_2}{uc}$$

$$\frac{7.38 \times 10^{-22}\ g\ CaCl_2}{uc} \times \frac{6.02 \times 10^{23}\ formula\ units}{1\ mole\ CaCl_2} \times \frac{1\ mole\ CaCl_2}{111.1\ g}$$

$$= \frac{4\ formula\ units\ CaCl_2}{uc}$$

2. A metal crystallizes in a cubic closest packing structure and its density is 9.25 g/cm^3. What is the molar mass of the metal, if the volume of its **atom** is 8.23×10^{-24} cm^3?

Answer: 61.8 g/mole

Calc a

vol atom $= \frac{4}{3}\pi r^3$

$8.23 \times 10^{-24}\ cm^3 = \frac{4}{3}\pi r^3$

$r = 1.25 \times 10^{-8}\ cm^3$

$$a = \frac{f}{\sqrt{2}} = \frac{4r}{\sqrt{2}} = \frac{4(1.25 \times 10^{-8}\ cm^3)}{\sqrt{2}} = 3.54 \times 10^{-8}\ cm$$

$$g/uc = \frac{9.25\ g}{cm^3} \times \frac{(3.54 \times 10^{-8}\ cm)^3}{uc} = \frac{41.1 \times 10^{-23}\ g}{uc}$$

$$mol/uc = \frac{4\ atoms}{uc} \times \frac{1\ mol}{6.02 \times 10^{23}\ atoms} = \frac{6.64 \times 10^{-24}\ mol}{1\ uc}$$

$$Molar\ mass = \frac{41.1 \times 10^{-23}\ g}{1\ uc} \times \frac{uc}{6.64 \times 10^{-24}\ mol}$$

$$= 61.8\ g/mol$$

3. a. Name the five types of crystalline solids.

i) Ionic ii) molecular iii) metallic iv) covalent network iv) nonbonding solid

b. Indicate the **type of crystalline solid** each of the following would form upon solidification. Tell what **type of particles** are located at the lattice points and the **types of attractive forces** that exist between the particles.

	Type of crystalline solid	Type of particles at lattice points	Attractive forces
S_8	Molecular	Molecules	IMF: Dispersion
HF	Molecular	Molecules	IMF: Hydrogen bonds
potassium permanganate	Ionic	cations & Anions	Electrostatic attraction (Ionic bonds)
Ni	Metalic	metal cations	Attraction between cations & sea of e^-
SiO_2	Covalent network	Atoms	Covalent Bonds

Set C :

1. Nickel has a cubic unit cell. The edge of the unit cell is 3.524×10^{-8} cm. The density of metallic nickel is 8.91 g/cm^3.
a) How many nickel atoms are in the unit cell?
b) Calculate the radius of a nickel atom based on your result of question (a) above.

Answer: a) 4 atoms b) 1.24×10^{-8} cm

(a)

$$\text{Vol}_{uc} = a^3 = (3.524 \times 10^{-8}\ \text{cm})^3 = 4.376 \times 10^{-23}\ \text{cm}^3$$

$$\text{g per uc} = \frac{4.376 \times 10^{-23}\ \text{cm}^3}{\text{uc}} \times \frac{8.91\ \text{g Ni}}{\text{cm}^3} = 3.90 \times 10^{-22}\ \frac{\text{g}}{\text{uc}}$$

$$\text{Atoms per uc} = 3.90 \times 10^{-22}\ \frac{\text{g}}{\text{uc}} \times \frac{1\ \text{mol Ni}}{58.69\ \text{g}} \times \frac{6.02 \times 10^{23}\ \text{atoms Ni}}{1\ \text{mol Ni}}$$

$$= 4\ \frac{\text{atoms}}{\text{uc}} \qquad \text{FCC}$$

(b)

$$a = \frac{f}{\sqrt{2}} = \frac{4r}{\sqrt{2}}$$

$$3.524 \times 10^{-8} = \frac{4r}{\sqrt{2}} \qquad r = 1.246 \times 10^{-8}\ \text{cm}$$

2. The volume of a metal **atom** is 7.24×10^{-24} cm^3. The metal crystallizes in a cubic closest packing structure. The density of the metal is 8.77 g/cm^3. What is the molar mass of the metal?

Answer : 51.5 g/mole

Calc a

$$\text{vol atom} = \frac{4}{3}\pi r^3$$

$$7.24 \times 10^{-24}\ \text{cm}^3 = \frac{4}{3}\pi r^3$$

$$r = 1.20 \times 10^{-8}\ \text{cm}$$

$$a = \frac{f}{\sqrt{2}} = \frac{4r}{\sqrt{2}} = \frac{4(1.20 \times 10^{-8}\ \text{cm})}{\sqrt{2}} = 3.39 \times 10^{-8}\ \text{cm}$$

$$\text{g per uc} = 8.77\ \frac{\text{g}}{\text{cm}^3} \times \frac{(3.39 \times 10^{-8}\ \text{cm})^3}{\text{uc}} = 3.42 \times 10^{-22}\ \frac{\text{g}}{\text{uc}}$$

$$\text{mol per uc} = 4\ \text{atoms} \times \frac{1\ \text{mol}}{6.02 \times 10^{23}\ \text{atoms}} = 6.64 \times 10^{-24}\ \frac{\text{mol}}{\text{uc}}$$

$$\text{Molar mass} = 3.42 \times 10^{-22}\ \frac{\text{g}}{\text{uc}} \times \frac{\text{uc}}{6.64 \times 10^{-24}\ \text{mol}} = 51.5\ \text{g/mol}$$

3. Indicate the **type of crystalline solid** each of the following would form upon solidification. Tell what **type of particles** are located at the lattice points and the **types of attractive forces** that exist between the particles.

	Type of crystalline solid	Type of particle(s) at lattice point	Attractive forces between lattice points
NH_4HSO_4	Ionic	cations & Anions	Electrostatic Attraction (Ionic Bonds)
SiO_2	Network covalent	Atoms	covalent Bonds
Si	Nonbonding	Atoms	IMF: Dispersion
HCl	Molecular	Molecules	IMF: Dipole-Dipole
Al	Metallic	metallic cations	Attraction between cations & sea of e-
I_2	Molecular	Molecules	IMF: Dispersion

4. Manganese crystallizes in a face-centered cubic system. The radius of the manganese **atom** is 1.30×10^{-8} cm. What is the density of manganese? Answer: 7.32 g/cm3

$$a = \frac{f}{\sqrt{2}} = \frac{4r}{\sqrt{2}} = \frac{4\,(1.30 \times 10^{-8}\ cm)}{\sqrt{2}} = 3.68 \times 10^{-8}\ cm$$

$$\text{Vol}_{uc} = a^3 = (3.68 \times 10^{-8}\ cm)^3 = \frac{4.98 \times 10^{-23}\ cm^3}{uc}$$

$$\text{g per uc} = \frac{4\ atoms}{uc} \times \frac{1\ mol\ Mn}{6.02 \times 10^{23}\ atoms} \times \frac{54.99\ g\ Mn}{1\ mol\ Mn}$$

$$= 3.65 \times 10^{-22}\ \frac{g}{uc}$$

$$\text{Density} = \frac{3.65 \times 10^{-22}\ g/uc}{4.98 \times 10^{-23}\ cm^3/uc} = 7.33\ g/cm^3$$

5. Associate each of the solids: CsI, SiO_2, Ni, and $SiCl_3H$ with one of the following sets of properties:

a) A very hard solid subliming at 2900 ° C. SiO_2

b) A yellowish solid having a melting point of 40 ° C and is a nonconductor of electricity in the molten state. $SiCl_3H$

c) A lustrous solid melting at about 1600 ° C . Both the solid and the liquid are electrically conductors. Ni

d) A white solid melting at about 700 ° C . The liquid is electrically conducting although the solid is not. CsI