

Do all Problems  
(110/100 Total Points)

QUIZ #1a  
MSEG 302

Name: Solutions

Write your answers below the question on this paper

2-1 (15 pts) How many atoms in 50 cm<sup>3</sup> of Lead (Pb) ?

$$N_A = 6.02 \times 10^{23} \text{ atoms/mol} \quad \rho = 11.36 \text{ g/cm}^3$$

$$\text{Atomic Mass} = 207.19 \text{ g/mol}$$

$$\text{Atoms of Pb} = 50 \text{ cm}^3 \times \frac{11.36 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ mol}}{207.19 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}}$$

$$\boxed{\text{Atoms of Pb} = 1.65 \times 10^{24} \text{ atoms}} \quad +15$$

Partial Deductions:

Missing Conversions  
Missing Portions of Answer [(ex.  $\times 10^n$ ) where  $n \neq 24$ ]

2-2 (15 pts) In order to plate a steel part having a surface area of 200 in<sup>2</sup> with a 0.002 inch thick layer of nickel, (a) how many atoms of nickel are required and (b) how many moles of nickel are required?

$$N_A = 6.02 \times 10^{23} \text{ atoms/mol} \quad \rho = 8.902 \text{ g/cm}^3$$

$$\text{Atomic Mass} = 58.71 \text{ g/mol} \quad 2.54 \text{ cm} = 1 \text{ inch}$$

$$\text{Volume} = (200 \text{ in.}^2)(0.002 \text{ in.})(2.54 \text{ cm}/1 \text{ in.})^3 = 6.555 \text{ cm}^3$$

$$\text{a) Atoms of Ni} = 6.555 \text{ cm}^3 \times \frac{8.902 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ mol}}{58.71 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}}$$

$$\boxed{\text{Atoms of Ni} = 5.98 \times 10^{23} \text{ atoms}} \quad +8$$

$$\text{b) Moles of Ni} = 6.555 \text{ cm}^3 \times \frac{8.902 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ mol}}{58.71 \text{ g}}$$

$$\boxed{\text{Moles of Ni} = 0.994 \text{ moles}} \quad +7$$

Partial Deductions:

Incorrect Volume Calculation  
Missing Conversions  
Missing Portions of Answer

$$a_0 = 3.5167 \text{ \AA}$$

Correct idea for PD & PF

$$a_0 = \frac{4r}{\sqrt{2}}$$

3-2 (15 pts) Determine the planar density and packing fraction for FCC nickel in the (100), (110), and (111) planes. Which, if any, of these planes is close packed? Planar Density =  $\frac{\text{Atomic Units}}{\text{Planar Area}}$  Packing Fraction =  $\frac{\text{Area Occupied by atoms}}{\text{Total Plane Area}}$

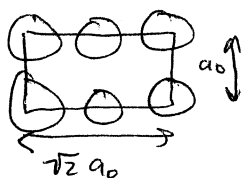
(100) Planar Density =  $\frac{2}{(3.5167 \times 10^{-8} \text{ cm})^2} = 1.617 \times 10^{15} \text{ points/cm}^2$  +1



Packing Fraction =  $\frac{2\pi r^2}{(4r/\sqrt{2})^2} = 0.7854$  +3

Planar Density =  $\frac{2}{\sqrt{2} (3.5167 \times 10^{-8} \text{ cm})^2} = 1.44 \times 10^{15} \text{ points/cm}^2$  +1

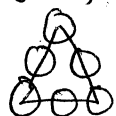
(110)



Packing Fraction =  $\frac{2\pi r^2}{\sqrt{2} (4r/\sqrt{2})^2} = 0.555$  +3

Planar Density =  $\frac{2}{0.866 (3.5167 \times 10^{-8} \text{ cm})^2} = 1.867 \times 10^{15} \text{ points/cm}^2$  +1

(111)



A =  $0.866 a_0^2$  Packing Factor =  $\frac{2\pi (\sqrt{2} a_0 / 4)^2}{0.866 a_0^2} = 0.907$  +3

The (111) is close-packed plane. +3

3-2 (20 pts) Determine the Miller indices for the directions (A, B, C and D) in the cubic unit cell shown.

A:  $0, 0, 1 - 1, 0, 0 = -1, 0, 1 = [\bar{1} 0 1]$  +5

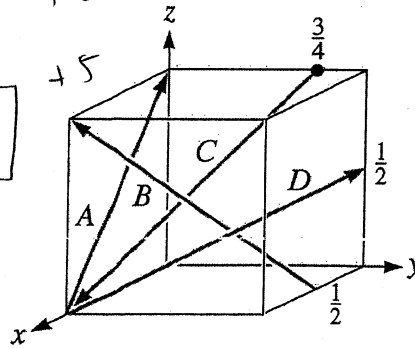
B:  $1, 0, 1 - \frac{1}{2}, 1, 0 = \frac{1}{2}, -1, 1 = [1 \bar{2} 2]$  +5

C:  $1, 0, 0 - 0, \frac{3}{4}, 1 = 1, -\frac{3}{4}, -1 = [4 \bar{3} \bar{4}]$  +5

D:  $0, 1, \frac{1}{2} - 0, 0, 0 = 0, 1, \frac{1}{2} = [0 2 1]$  +5

OR

$0, 1, \frac{1}{2} - 1, 0, 0 = -1, 1, \frac{1}{2} = [\bar{2} 2 1]$



Partial Deductions:

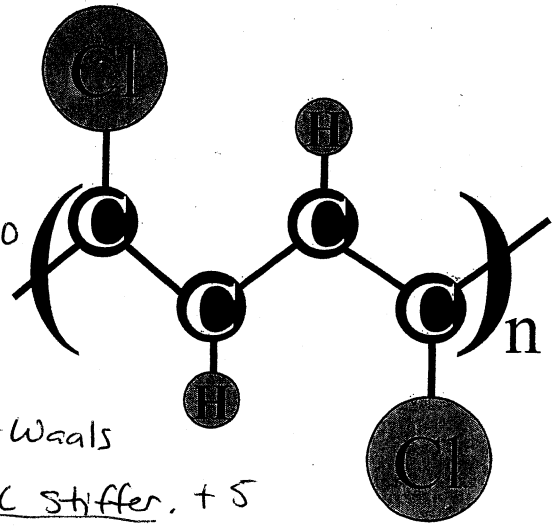
Switching order of subtraction

Incorrect form

Not clearing fractions

2-3 (15) Explain the role of van der Waals forces in PVC plastic

In PVC, the chlorine atoms attached to the polymer chain have a negative charge and the hydrogen atoms are positively charged. The chains are weakly bonded by Van der Waals bonds. The additional bonding makes PVC stiffer. +5



Partial Credit if Mention:

H + Cl (but not charges)

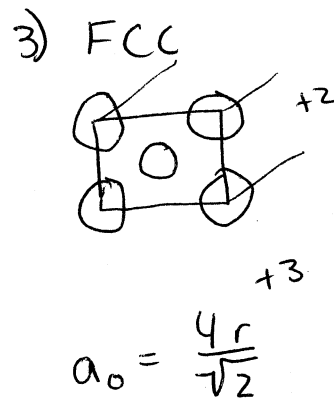
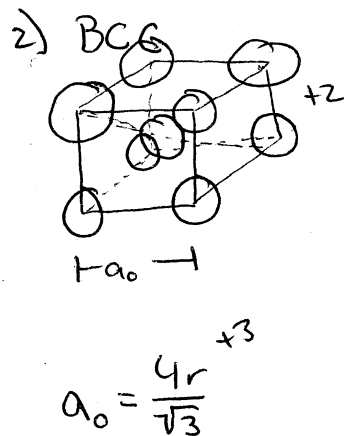
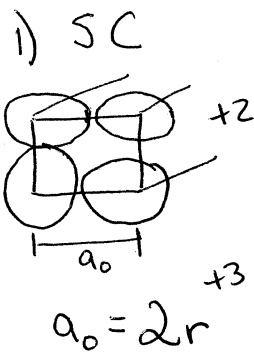
Dipole

Strength Enhanced

3-1 (15 pts) Derive the relationship between atomic radius ( $r$ ) and the lattice parameter ( $a_0$ ) for

- 1) simple cubic
- 2) body-centered cubic
- 3) face-centered cubic

Sketch unit cell and show derivation.



Partial Deductions:

Not showing atoms

Do all Problems  
(110/100 Total Points)

QUIZ #1b  
MSEG 302

Name: Solutions

Write your answers below the question on this paper

- 2-1 (15 pts) How many atoms in  $75 \text{ cm}^3$  of Lead (Pb) ?  
 $N_A = 6.02 \times 10^{23} \text{ atoms/mol}$        $\rho = 11.36 \text{ g/cm}^3$   
Atomic Mass =  $207.19 \text{ g/mol}$

$$\text{Atoms of Pb} = 75 \text{ cm}^3 \times \frac{11.36 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ mol}}{207.19 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}}$$

$$\boxed{\text{Atoms of Pb} = 2.48 \times 10^{24} \text{ atoms}} \quad +15$$

Partial Deductions:

Missing Conversions  
Missing Portions of Answer

- 2-2 (15 pts) In order to plate a steel part having a surface area of  $200 \text{ in}^2$  with a  $0.003 \text{ inch}$  thick layer of nickel, (a) how many atoms of nickel are required and (b) how many moles of nickel are required?

$$N_A = 6.02 \times 10^{23} \text{ atoms/mol} \quad \rho = 8.902 \text{ g/cm}^3$$
$$\text{Atomic Mass} = 58.71 \text{ g/mol} \quad 2.54 \text{ cm} = 1 \text{ inch}$$

$$\text{Volume} = (200 \text{ in}^2)(0.003 \text{ in}) \left( \frac{2.54 \text{ cm}}{1 \text{ in.}} \right)^3 = 9.832 \text{ cm}^3$$

$$\text{a) Atoms of Ni} = 9.832 \text{ cm}^3 \times \frac{8.902 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ mol}}{58.71 \text{ g}} \times \frac{6.02 \times 10^{23} \text{ atoms}}{1 \text{ mol}}$$

$$\boxed{\text{Atoms of Ni} = 8.975 \times 10^{23} \text{ atoms}} \quad +8$$

$$\text{b) Moles of Ni} = 9.832 \text{ cm}^3 \times \frac{8.902 \text{ g}}{1 \text{ cm}^3} \times \frac{1 \text{ mol}}{58.71 \text{ g}}$$

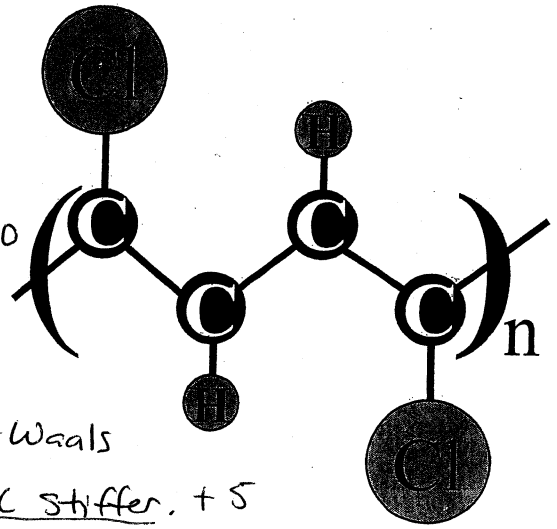
$$\boxed{\text{Moles of Ni} = 1.491 \text{ moles}} \quad +7$$

Partial Deductions:

Incorrect Volume Calculation  
Missing Conversion  
Missing Portions of Answer

2-3 (15) Explain the role of van der Waals forces in PVC plastic

In PVC, the chlorine atoms attached to the polymer chain have a negative charge and the hydrogen atoms are positively charged. The chains are weakly bonded by Van der Waals bonds. The additional bonding makes PVC stiffer. +10 +5



Partial Credit if Mention:

H + Cl (but not charges)

Dipole

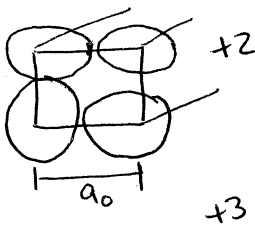
Strength Enhanced

3-1 (15 pts) Derive the relationship between atomic radius ( $r$ ) and the lattice parameter ( $a_0$ ) for

- 1) simple cubic
- 2) body-centered cubic
- 3) face-centered cubic

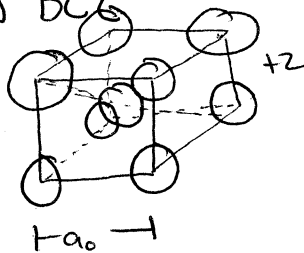
Sketch unit cell and show derivation.

1) SC



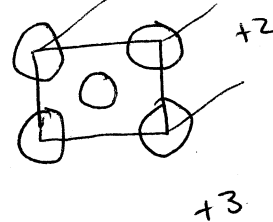
$$a_0 = 2r$$

2) BCC



$$a_0 = \frac{4r}{\sqrt{3}}$$

3) FCC



$$a_0 = \frac{4r}{\sqrt{2}}$$

Partial Deductions:

Not showing atoms



3-3 (15 pts) Determine the Miller indices for the planes (A, B and C) in the cubic unit cell shown.

A: (origin @ 1, 0, 0)

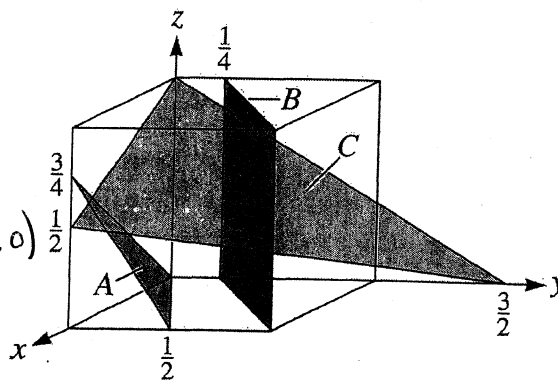
$$x = -1 \quad \frac{1}{x} = -1 \times 3 = -3$$

$$y = \frac{1}{2} \quad \frac{1}{y} = 2 \times 3 = 6$$

$$z = \frac{3}{4} \quad \frac{1}{z} = \frac{4}{3} \times 3 = 4$$

$$\boxed{(\bar{3} \ 6 \ 4)}$$

Also accept  $(3 \bar{6} \ 4)$  w/origin @ (0,0,0)



+5

B: (origin @ 0, 1, 0)

$$x = 1 \quad \frac{1}{x} = 1 \times 3 = 3$$

$$y = -\frac{3}{4} \quad \frac{1}{y} = -\frac{4}{3} \times 3 = -4$$

$$z = \infty \quad \frac{1}{z} = 0 \times 3 = 0$$

$$\boxed{(3 \ \bar{4} \ 0)}$$

+5

Also accept  $(\bar{3} \ 4 \ 0)$  w/origin @ (0,0,0)

C: (origin @ (0,0,0))

$$x = 2 \quad \frac{1}{x} = \frac{1}{2} \times 6 = 3$$

$$y = \frac{3}{2} \quad \frac{1}{y} = \frac{2}{3} \times 6 = 4$$

$$z = 1 \quad \frac{1}{z} = 1 \times 6 = 6$$

$$\boxed{(3 \ 4 \ 6)}$$

+5

Partial Deductions:

Not clearing fractions

Not inverting

Not in correct form

Partial Credit:

x, y, or z correct