Chemistry II-AP

Solids – Crystal Types – Problem Set

Solution Set

1. How many atoms are there of element M in a unit cell if the element exhibits a **face-centered cubic arrangement (atoms are located in the faces and at the corners)?**

 A) 1; B) 2; C) 3; **D) 4;** E) 6; F) 12 - the same as its coordination number.

 **= 8(1/8) + 6(1/2) = 1 + 3 = 4**

2. What is the empirical formula of a binary ionic crystal in which element “A” is located on the corners and element “B” is located in the faces of the crystal?

 **“A” = 8(1/8) = 1 “B” = 6(1/2) = 3 🡺 AB3**

3. What is the empirical formula of a binary ionic crystal in which element “A” is located on alternating corners and element “B” is located in the faces and the remaining corners?

 **“A” = 4(1/8) = 1/2 “B” = 6(1/2) + 4(1/8) = 7/2 🡺 AB7**

4. What is the distance between layers (**innm**) in a crystalline solid if the first order of refraction of

X-rays with a wavelength of **105 nm** requires an angle of **20.0o**?

 **n = 2dsin==> d = (1)(105 nm) / (2)(sin(20.0)) = 153 nm**

5. The density of a metal that exhibits a simple cubic crystalline (SC) arrangement is 7.54 g/cm3.

 The atomic weight is 166.0 g/mole. What is the radius of an atom (in nm) of this metal?

 **Need volume:**

 **1cm3 166.0 g 1 mole 1 atom**

 **-------- x ------------ x ----------- x ------------ = V = 3.66 x 10-23 cm3**

 **7.54 g 1 mole Av. # 1 cell**

 **V = E3 🡺 E = 3.32 x 10-8 cm = 0.332 nm = 4r / (2)1/2 🡺 r = 0.117 nm**

6. What is the **wavelength (in Angstroms)** in a solid crystal if a second-order Xray diffraction

 shows a distance of **185.0 nm** to produce an **angle of diffraction of 23.3o**?

 **n = 2dsin==> = [(2)(1850 Å)(0.3955)] / 2 = 732 Angstroms**

7. An ionic crystal consists of elements A, B, and C - all contained within one unit cell. If A is found on alternating corners and alternating faces, B is on alternating faces, and C is on alternating corners, what is the empirical formula of this compound?

**A: 4(1/8) + 1(1/2) = 1 Formula: A2BC**

**B: 1(1/2) = 0.5**

**C: 4(1/8) = 0.5**

8. What is the calculated density (in g/cm3) of a solid metallic elemental substance that has an atomic weight of 197.0 gram/mole, given that it exhibits a face-centered cubic arrangement? The radius of an atom of this element is 1.444 Angstroms.

**Radius = 1.44 Å = 1.44x10-8 cm**

**Cube length = (4r/sqrt(2)) = 4(1.44x10-8)/sqrt(2) = 4.10x10-8cm**

**Volume = (length)3 = 6.8921x10-23 cm3**

**D = M/V = [(4 atoms \* 197.0 g/mol \* (1mol/6.022x1023 atoms)]/6.8921x10-23 cm3 = 18.986 g/cm3**

**D = 18.99 g/cm3**

9. Calculate Avogadro’s number, using the following data: a sample of a pure elemental solid exhibits a body-centered crystalline pattern. It has a density of 6.095 g/cm3. The atomic mass is 130.3 g/mol, and the atomic radius is 1.84 Angstroms.

**BCC = 1 + 4(1/4) = 2 atoms/unit cell**

|  |  |  |  |
| --- | --- | --- | --- |
| **130.3 g subs** | **1 cm3** | **1 unit cell** | **2 atoms** |
| **1 mol** | **6.095 g subs** | **7.68x10-23 cm3** | **1 unit cell** |

**= 5.57x1023 atoms / mol**

**Compare this to the actual value of avogadro’s number. Pretty close!**

10. A compound is composed of elements A, B, and C. The solid has atoms of A in a BCC and at alternating sites of a simple cubic; B is alternating FCC; C is alternating FCC and occupies the other corners of the simple cubic. What is the empirical formula of the compound?

**A: 1 + 4(1/8) = 1 + ½ = 1.5**

**B: 3(1/2) = 3/2 = 1.5**

**C: 3(1/2) + 4(1/8) = 3/2 + ½ = 2 Formula: A3B3C4**

11. What is the calculated density of element M if its solid form exhibits FCC,

its MW = 221.5 g/mole, and its atomic radius is 2.01 Angstroms?

**Radius = 2.01 Å = 2.01x10-8 cm**

**Cube length = (4r/sqrt(2)) = 4(2.01x10-8)/sqrt(2) = 5.69x10-8 cm**

**Volume = (length)3 = 1.84x10-22 cm3**

**D = M/V = [(4 atoms \* 221.5 g/mol \* (1mol/6.022x1023 atoms)]/ 1.84x10-22 cm3= 7.996 g/cm3**

**D = 7.996 g/cm3**

12. What is the term for the type of liquid crystal in which layers are arranged in only one dimension?

**Nematic / smectic**

13. What is the term for the type of liquid crystal in which layers are arranged in two dimensions?

**cholosteric**

14. The distance between layers is 610.1 nm in a crystalline solid. The first order of refraction of

X rays with a wavelength of 554 nm requires what angle?

**nλ = 2d sinθ ==> θ = sin-1 (nλ / 2d) = 27.00°**

**Is your calculator in degree mode?**

15. What is the calculated atomic mass of element Z if its solid form exhibits BCC, its density is

 7.88 g/mL, and its atomic radius is 0.155 nm?

**0.155 nm = 1.55x10-8 cm**

**V = (1.55x10-3cm)3 = 3.72x10-24 cm3**

|  |  |  |  |
| --- | --- | --- | --- |
| **3.72x10-24 cm3** | **7.88 g Z** | **1 unit cell** | **6.022x1023 atoms Z** |
| **1 unit cell** | **1 cm3** | **2 atoms Z** | **1 mol** |

**= 8.83 g / mol**

16. This 4th period transition metal exhibits a body-centered cubic arrangement. It has a density of

 7.19 g/mL and an atomic radius of 1.25 Angstrom. What is the ID of this element?