Exam 1

Thursday, September 30, 2021 3:35 PM

Question 12

B.1 (a) Calculate the % ionic character in a compound AB_2 if the electronegativities of Y and X are 0.7 and 3 respectively.

(b) On the basis of the result in (a), what type(s) of interatomic bonding would you expect to be dominant in AB_2?

a.) $\%\ IC = \left(1 - e^{(-(Y-X)^2/4)}\right) \times 100$

$\%\ IC = \left(1 - e^{\frac{(-(0.7-3)^2}{4}}\right) \times 100$

$\%\ IC = 73.35\%$

b.) Mainly Ionic bonds

Question 13 10 pts

Part B.2: If the energy of attraction between a divalent anion and a monovalent cation is -1.7 x 10^{-18} J, calculate their internuclear distance of separation [in nm].

$F(r) = \frac{|Z_1 Z_2| e^2}{4\pi\varepsilon_0 r^2}$

$J = \frac{N}{1m}$

$-1.7\times10^{-18} = \frac{2(1.602\times10^{-19})^2}{4\pi(8.85\times10^{-12})r^2}$

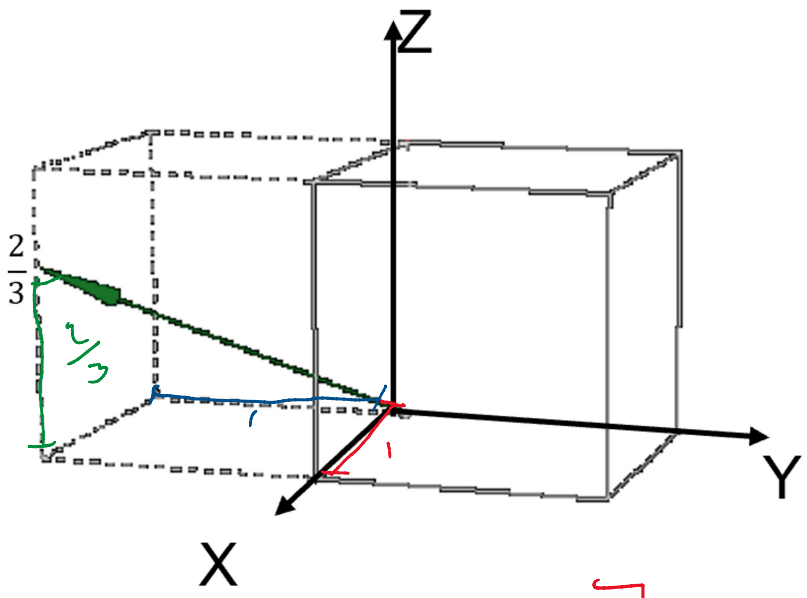
N per 1m

$1.891\times10^{-28} = \frac{5.183E^{-38}}{r^2}$

$r = \sqrt{\frac{5.183\times10^{-38}}{1.891\times10^{-28}}} = 1.647E\text{-}5 = 16470\ nm$

Question 14

Part B.3: Determine the direction's indices in the cubic unit cell below

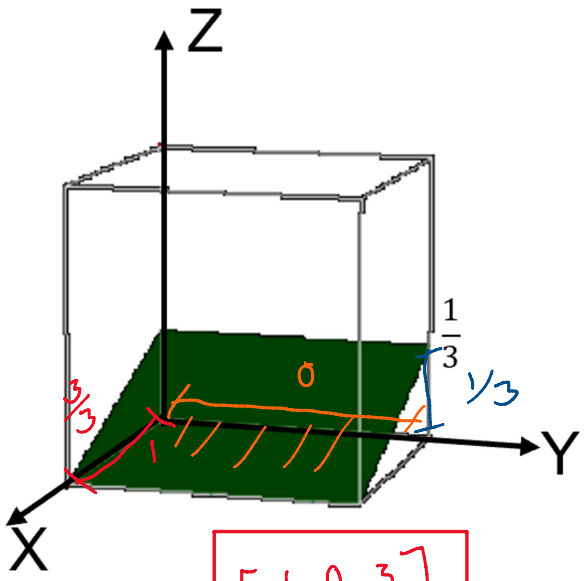


$$3\left[\left(1, -1, \frac{2}{3}\right)\right]$$

$$= \boxed{[3\ \bar{3}\ 2]}$$

Question 15

Part B.4: Determine the plane's indices in the cubic unit cell below.



$\frac{1}{1} - 0 = 1$

$0 - 0 = 0$

$\frac{3}{1} - 0 = 3$

[1 0 3]

Question 16

10 pts

Part B.5: Determine the theoretical density of a hypothetical metal having a BCC crystal structure [in **g/cm^3**] if the metal has an atomic radius of 0.19 nm and an atomic weight of 100.5 g/mol.

$$\rho = \frac{nA}{V_c N_A}$$

$$V_c = \left(\frac{4R}{\sqrt{3}}\right)^3$$

$$V_c = \left(\frac{(1.9 \times 10^{-8})(4)}{\sqrt{3}}\right)^3$$

$$V_c = 8.498 \times 10^{-23}$$

$$\rho = \frac{(2)(100.5)}{(8.498 \times 10^{-23})(6.022 \times 10^{23})}$$

$\rho = 3.95$ g/cm^3

Question 17

10 pts

Part B.6: A pure FCC metal sample was analyzed with an X-ray beam of wavelength 0.075 nm and the observed diffraction angle for the first-order reflection from the (211) set of planes was 27.1°. Calculate the atomic radius of the metal and identify the metal

$$d = \frac{n\lambda}{2\sin(\theta)}$$

$$d = \frac{(1)(0.075\times10^{-9})}{2\sin(27.1^\circ)} = 8.23\times10^{-11}$$

$$a = \frac{4R}{\sqrt{2}} = d\sqrt{(h)^2+(k^2)+(l^2)}$$

$$\frac{4R}{\sqrt{2}} = (8.23\times10^{-11})\sqrt{6}$$

$$R = 7.13\times10^{-11}\ m = \boxed{0.0713\ nm}$$

$$\boxed{\text{The metal is } Mg^{2+}}$$

Question 18

10 pts

Part B.7: Calculate the temperature [in **K**] required to increase the fraction of vacancies in a metal from 0.5x10-5 to 1.5x10-5, if the energy of vacancy formation in is 2.1 eV/atom.

$$\frac{N_v}{N} = \exp\left(\frac{-Q_v}{k_B T}\right)$$

$$\frac{1.5\times10^{-5}}{0.5\times10^{-5}} = \exp\left(\frac{-2.1}{(8.617\times10^{-5})T}\right)$$

$$\ln(3) = -\frac{2.1}{kT}$$

$T = 22182.92\ K$