**Engineering Materials, Course No. 4202402, CCU ME**
Mid-term Exam (I)   **99. 10. 28.**   **Lectured by:敖仲寧**

1. Total score: 120, 2. Close-book, 3. Using calculator is allowed, 4. Keep question sheets and return answering sheets.

1. (a) List all primary and secondary interatomic bonds and give a sketch example of each bond. **(15%)**

(b) Briefly describe the conditions for the formation of an ionic bond between atoms. **(5%)**
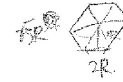
2. (a) Sketch a tetragonal unit cell and a monoclinic unit cell and give for each crystal system the lattice constants (a, b, c) relationship and interaxial angles (α, β, γ) relationship. **(8 %)**

(b) How many bravais crystal systems are there? **(2 %)**

3. (a) What is the atomic packing factor APF of an FCC and a HCP atomic structure? **(3 %)**

(b) If the APF of an FCC and a HCP atomic structure has the same value, explain why they have the same value? **(6 %)**

(c) In spite of having the same value of APF, why FCC and HCP looks different? **(6 %)**

(To answer b and c, you have to sketch the features of the atomic arrangement in FCC and in HCP to give your explanations.)

4. (a) Show that the minimum cation-to-anion radius ratio r/R for the CN=3 is 0.155 **(6%)**

(b) List all the polymorphic forms of carbon (either in English or Chinese). (Do not sketch atomic structure.) **(6%)**

(c) To what contribution was the Nobel Prize of Physics 2010 granted? **(3%)**

5. (a) Determine the angle between crystallographic planes (1 1 1) and direction [1 1 0].. **(5%)**

(b) Find the Miller indices of a plane determined by the crystallographic direction [1 $\underline{1}$ 1] and [2 $\underline{1}$ 0]. **(5%)**

6. X-ray diffraction on a pure metal reveals diffraction patterns with first
five peaks at $2\theta = 32.3°, 37.5°, 54.1°, 64.4°$, and $67.6°$, the wave
length of X-ray from a Co target is $\lambda = 0.17902$ nm.

(a) Index the planes (h k l) of these five peaks. **(10%)**

(b) Determine the interplanar spacing of the first peaks **(5%)**

(c) For the first peaks, determine the atomic radius of this metal. **(5%)**

(d) What should this metal be? (Check table) **(3%)**

(e) In the figure below, which index (or which indices) of the
diffraction peak (or peaks) may be wrong? Briefly give your reasons.
(7%)
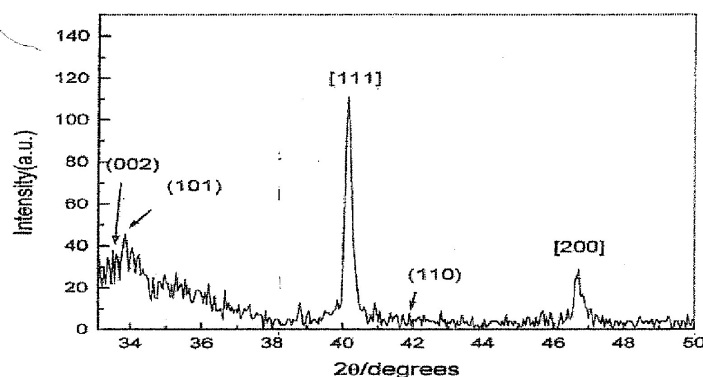
Characteristics of Selected Elements

Element	Symbol	Atomic Number	Atomic Weight (amu)	Density of Solid, 20°C (g/cm³)	Crystal Structure, 20°C	Atomic Radius (nm)	Ionic Radius (nm)	Most Common Valence	Melting Point (°C)
Aluminum	Al	13	26.98	2.71	FCC	0.143	0.053	3+	660.4
Argon	Ar	18	39.95	—	—	—	—	Inert	−189.2
Barium	Ba	56	137.33	3.5	BCC	0.217	0.136	2+	725
Beryllium	Be	4	9.012	1.85	HCP	0.114	0.035	2+	1278
Boron	B	5	10.81	2.34	Rhomb.	—	0.023	3+	2300
Bromine	Br	35	79.90	—	—	—	0.196	1−	−7.2
Cadmium	Cd	48	112.41	8.65	HCP	0.149	0.095	2+	321
Calcium	Ca	20	40.08	1.55	FCC	0.197	0.100	2+	839
Carbon	C	6	12.011	2.25	Hex.	0.071	~0.016	4+	(sublimes at 3367)
Cesium	Cs	55	132.91	1.87	BCC	0.265	0.170	1+	28.4
Chlorine	Cl	17	35.45	—	—	—	0.181	1−	−101
Chromium	Cr	24	52.00	7.19	BCC	0.125	0.063	3+	1875
Cobalt	Co	27	58.93	8.9	HCP	0.125	0.072	2+	1495
Copper	Cu	29	63.55	8.94	FCC	0.128	0.096	1+	1085
Fluorine	F	9	19.00	—	—	—	0.133	1−	−220
Gallium	Ga	31	69.72	5.90	Ortho.	0.122	0.062	3+	29.8
Germanium	Ge	32	72.59	5.32	Dia. cubic	0.122	0.053	4+	937
Gold	Au	79	196.97	19.32	FCC	0.144	0.137	1+	1064
Helium	He	2	4.003	—	—	—	—	Inert	−272 (at 26 atm)

1. (a) primary: 金屬鍵. 共價鍵. 離子鍵   +6

ex. Cu CO_2 NaCl

secondary: 凡德瓦爾力. 氫鍵 +1

ex. CO_2 分子間 H_2O 分子間

(b) 正離子有顆電子跑到負離子那, 而正離子的電子形成 +1
離子鍵, 形成穩定態. ex. Na → Cl

2. (a) tetragonal   monoclinic (b)

$a \neq b \neq c$

$a \neq b = c$

14 種 +2

$\alpha = \beta = \gamma = 90°$

$\alpha = \beta = 90°$
$\gamma \neq 90°$

+1

3. (a)
FCC and HCP 的 APF = 0.74

(b) 它們有同樣的配位數, 且 FCC在某特定角度看跟HCP一樣
HCP   FCC   +1   皆為最密堆積

(c) FCC → ACBACB   HCP → ABABAB

 A C B   A B A

+6

(a)

(b) ✗ ✗0
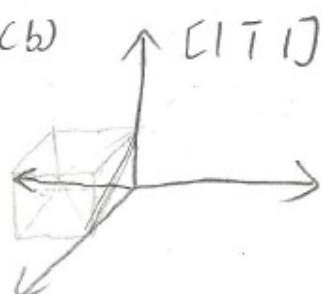
(c) C_{60}

5. (a) (1 1 1)

$\alpha = \beta = \gamma = 60°$
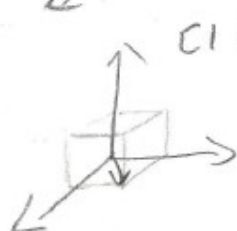
[1 1 0]

$\alpha = \beta = 45°$ $\gamma = 0°$

✗0

(b) [1 $\bar{1}$ 1]

plane = (1 $\bar{1}$ 1)

[2 $\bar{1}$ 0]
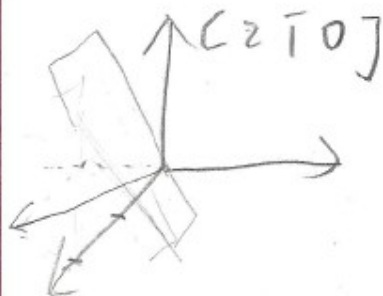
plane = (2 $\bar{1}$ 0)

2θ	θ	$\sin\theta$	$\sin^2\theta$	$h^2+k^2+l^2$	(hkl)	K
32.3	16.15	0.2781	0.0774	3	(111)	38.7597
37.5	18.75	0.3214	0.1033	4	(200)	38.7222
54.1	27.05	0.4548	0.2068	8	(220)	38.6847
64.4	32.2	0.5329	0.2840	11	(311)	38.7324
67.6	33.8	0.5563	0.3095	12	(222)	38.7722

(a)
$$(111)\ (200)\ (220)\ (311)\ (222)$$

(b)
$(111)\ \ \ n\lambda = 2d\sin\theta \qquad d = \dfrac{a}{\sqrt{h^2+k^2+l^2}}$

$$d = \frac{0.1790z}{2\times\sin 16.15°} = 0.3218\ (nm)$$

+10

$$a = 0.3218\times\sqrt{3} = 0.5574\ (nm)$$

$$體積 = a^2 = 0.3107\ (nm^2)$$

+5

(c)
$$FCC \Rightarrow a = \frac{4}{\sqrt{2}}R$$

$$R = \frac{\sqrt{2}}{4}\times 0.5574 = 0.1971\ (nm)$$

+5

(d)
$$Ca$$

+5

(e) (002)、(110) are wrong

　因為 (002) 跟 (200) 是 family 但它卻在 (111) 之前
　　(110)也在 (111) 之後
　且由於 (111) 和 (200) 相當明顯，所以應是 FCC
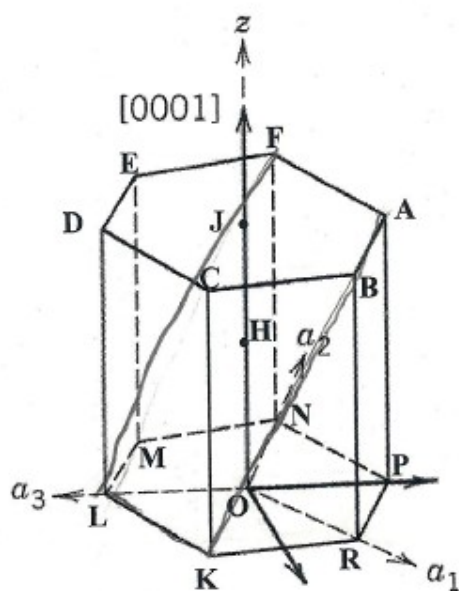$A \doteq$ ∴ (002)、(101)、(110) are wrong #

+3

7. Determine Miller-Bravais indices *step by step!*
    (a) Plane FAKL (this plane also passes through point H) **(5%)**
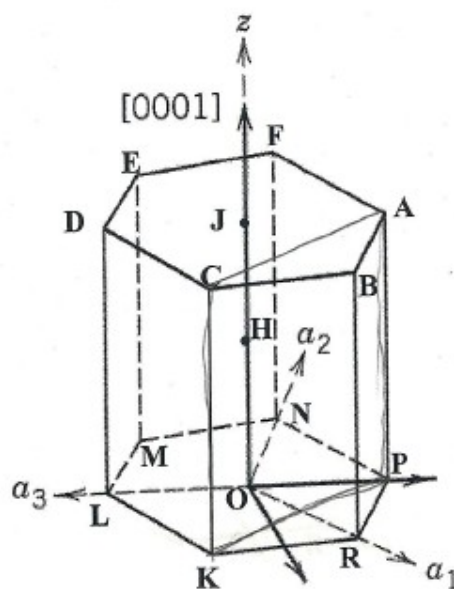   (b) Plane APKC **(5%)**

(a)

$(a_1 \quad a_2 \quad a_3 \quad z)$

$\Rightarrow (\infty \quad \bar{1} \quad 1 \quad \frac{1}{2})$

$\Rightarrow (0 \quad \bar{1} \quad 1 \quad 2)$ ✓

互換

(b)

$(a_1 \quad a_2 \quad a_3 \quad z)$

$\Rightarrow (\frac{1}{2} \quad \bar{1} \quad \bar{1} \quad \infty)$

$\Rightarrow (2 \quad \bar{1} \quad \bar{1} \quad 0)$ ✓

+8

7. (c) Determine Miller-Bravais indices of direction <u>JT</u> as indicated. **(5%)**

(d) Sketch the [1 1 <u>2</u> 3] direction. **(5%)**

(c) $(a_1 \quad a_2 \quad a_3 \quad z)$

$\Rightarrow (\frac{1}{3} \quad \frac{2}{3} \quad \cancel{\frac{-2}{3}} \quad 0)$

(d)

$(1 \quad 1 \quad \overline{2} \quad 3)$

$= (\frac{1}{6} \quad \frac{1}{6} \quad \overline{\frac{1}{3}} \quad \frac{1}{2})$

$= (\frac{1}{3} \quad \frac{1}{3} \quad \overline{\frac{2}{3}} \quad 1)$

+5