SCHOOL OF MINING, METALLURGY & CHEMICAL ENGNEERING

DEPARTMENT OF METALLURGY

National Diploma: Physical Metallurgy

SUBJECT:	**Physical Metallurgy 1**
CODE:	**PMY 11-1**
ASSESSMENT:	**Supplementary Exam Summer 2019**
WEIGHT:	**40:60**
EXAMINAR:	**Mr OJ Sanumi**
MODERATOR:	**Mr TG Langa**
DURATION:	**3 hours**
TOTAL MARKS:	**104**
FULL MARKS:	**100**

INSTRUCTIONS:

- **Use the appendices provided at the end of the question paper to answer some of the questions**
- **Scientific calculator is permitted**
- **Answer all the questions**

QUESTION 1: (35 Marks)

1.1 State the Pauli's exclusion principle **(5)**

1.2 Calculate the atomic packing factor (APF) for FCC crystal structures. **(10)**

1.3 The maximum number of atoms in the L shell (n=2) is

(a) 6 (b) 4 (c) 14 (d) 8 **(2)**

1.4 Calculate the theoretical density of Aluminum FCC with atomic radius of 0.143nm and atomic mass of 27 g/mol. **(15)**

1.5 Discuss the Octect rule with respect to the stable electronic configuration **(3)**

QUESTION 2: (35 Marks)

2.1 Show that the unit cell length (a_0) for a faced center cubic (FCC) with atomic radius R, are related through: $a_0 = \frac{4R}{\sqrt{2}}$ **(10)**

2.2 It is very possible for a crystalline quartz (SiO_2) to become amorphous. Under what condition does this happen? **(5)**

2.3 Calculate the critical radius (r^*) when solid Nickel forms by homogenous nucleation. The solid-liquid interfacial energy for Nickel is 255×10^{-3} J/m^2. Check appendix for other parameters. **(10)**

2.4 From question (2.3), calculate the number of atoms found in the critical nucleus of the solid Nickel formed. Assuming the lattice parameter of a Nickel FCC crystal is 0.1246nm. **(10)**

QUESTION 3: (24 Marks)

3.1 Name the elements of the following electronic configuration:

(a) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$
(b) $1s^2 2s^2 2p^6 3s^2 3p^6$
(c) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^1$
(d) $1s^2 2s^2 2p^5$ **(12)**

3.2 From the Aufbau's principle, what is the expected electronic configuration of the following elements:

(a) Na^+
(b) Cr^{2+}
(c) Mg^{2+}
(d) Si **(12)**

QUESTION 4: (10 Marks)

4.1 Write down the Gibbs phase rule, assuming the temperature and pressure are allowed change. Clearly explain the meaning of each term of the Gibbs phase rule. **(10)**

**** END ****

APPENDIX

Atomic Packing Factor (APF) = $\frac{(No\ of\frac{Atoms}{Cell})(Volume\ of\ each\ atom)}{Volume\ of\ unit\ cell}$

Theoretical density (ρ) = $\frac{n \times A}{V_c \times N_A}$

$$\frac{V_{r^*}}{V_{unit\ cell}}$$

1 nanometer (nm) = 10^{-9} m = 10^{-7} cm = 10 Å

1 angstrom (Å) = 0.1 nm = 10^{-10} m = 10^{-8} cm

Avogadros' Constant = 6.022 × 10^{23} atoms/mol

$$r^* = \frac{2\sigma_{sl}T_m}{\Delta H_f \Delta T}$$

Table 9-1 Values for freezing temperature, latent heat of fusion, surface energy, and maximum undercooling for selected materials

Material	Freezing Temperature (T_m) (°C)	Heat of Fusion (ΔH_f) (MJ/m^3)	Solid-Liquid Interfacial Energy (σ_{sl}) (J/m^2)	Typical Undercooling for Homogeneous Nucleation (ΔT) (°C)
Ga	30	488	56×10^{-3}	76
Bi	271	543	54×10^{-3}	90
Pb	327	237	33×10^{-3}	80
Ag	962	965	126×10^{-3}	250
Cu	1085	1628	177×10^{-3}	236
Ni	1453	2756	255×10^{-3}	480
Fe	1538	1737	204×10^{-3}	420
NaCl	801			169
CsCl	645			152
H_2O	0			40

Key

29 — Atomic number
Cu — Symbol
63.55 — Atomic weight

Metal

Nonmetal

Intermediate

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII	VIII	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA	0
1 H 1.0080																	2 He 4.0026
3 Li 6.941	4 Be 9.0122											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.87	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.69	29 Cu 63.55	30 Zn 65.41	31 Ga 69.72	32 Ge 72.64	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.30
55 Cs 132.91	56 Ba 137.33	Rare earth series	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.2	76 Os 190.23	77 Ir 192.2	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.19	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	Acti- nide series	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)								

Rare earth series	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
Actinide series	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)