Materials Science and Engineering Department

MSE 200-002, Exam #1, Spring 2009

ID number _____ *First letter of your last name:* ____

*Name:*_____

No notes, books, or information stored in calculator memories may be used. Cheating will be punished severely. All of your work must be written on these pages and turned in. Mark your answer on this paper first, and then copy onto the answer sheet at the end of the test. **Use #2 pencil to mark the answer sheet.**

Constants, equations, and other data are given on the last page of the exam.

Multiple choices (3 points each):

____ 1. Each element is characterized by a unique atomic number (Z), which indicates
- A. the number of protons plus neutrons in the nucleus
- B. the number of protons in the nucleus
- C. the number of neutrons in the nucleus
- D. the atomic weight of the element

____ 2. The electron configuration of the Fe ion by using *spdf* notation is (atomic number of Fe is 26):
- A. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6 4s^2$
- B. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5$
- C. $1s^2 2s^2 2p^6 3s^2 3p^6 3d^6$

____ 3. The electron configuration of sodium ($1s^2 2s^2 2p^6 3s^1$) indicates that it
- A. is very electronegative.
- B. is very electropositive.
- C. is a noble gas.
- D. tends to attract another electron

____ 4. A covalent bond forms by
- A. transferring of an electron from one atom to another
- B. sharing an electrons between two atoms
- C. sharing electrons among all atoms

❖ **For the following two problems**: A gold wire is 0.7 mm in diameter and 8.0 cm in length. Gold has a density of 19.3 g/cm^3 and an atomic weight of 196.97 g/mol.

____ 5. The weight of this wire gold is:
A. 0.5942 g B. 59.42 g C. 196.97 g

____ 6. The total number of Au atoms in the wire are:
A. 1.82×10^{21} atoms B. 1.82×10^{-22} atoms C. 19.3 atoms

❖ **For the following three problems**: 100 g of solder contains 52 wt% tin (Sn) and 48 wt% lead (Pb). The atomic weight of Sn is 118.7 g/mol, and the atomic weight of Pb is 207.2 g/mol.

____ 7. No. of mole of Sn in the solder is:

A. 0.843 mol B. 0.559 mol C. 0.4381 mol

____ 8. No. of mole of Pb in the solder is:

A. 0.1333 mol B. 1.2317 mol C. 0.2317 mol

____ 9. How many nearest neighbors does an atom have in a body-centered cubic (bcc) structure?

A. 4
B. 6
C. 8
D. 12

____ 10. In an fcc structure, the atoms contact each other along

A. Cube diagonal
B. Face diagonal
C. Edge

____ 11. In a fcc structure, the lattice constant, a, and the atom radius, R, have the following relationship:

A. $a = 4R/\sqrt{3}$
B. a = 2R
C. $a = 4R/\sqrt{2}$

____ 12. The following crystals have the highest packing factor:

A. bcc and fcc
B. bcc and hcp
C. fcc and hcp
D. hcp

____ 13. The number of atoms in a unit cell of bcc, fcc and hcp metals are

A. 4, 2, 6, respectively
B. 6, 4, 2, respectively
C. 2, 4, 6, respectively
D. none of the above

____ 14. [101] direction is on

A. (101) plane
B. (111) plane
C. $(1\,\bar{1}\,1)$ plane
D. $(\bar{1}11)$ plane

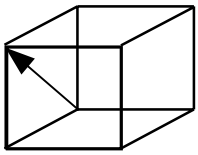
____ 15. The close packed direction in a fcc crystal is in which crystallographic direction?:

A. <100>
B. <110>
C. <111>
D. <210>

____ 16. Planes in a family of crystallographic planes
A. are always close packed
B. are always parallel
C. are represented by "{hkl}"
D. all of the above

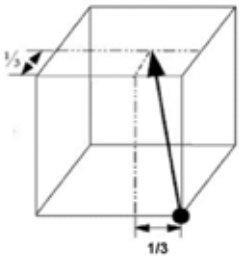
____ 17. The direction indices for the crystallographic direction indicated by the vector is

A. [111]
B. [100]
C. [110]
D. [101]



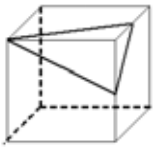
____ 18. The direction indices for the crystallographic direction indicated by the vector is

A. $[\bar{1}03]$
B. $[31\bar{1}]$
C. $[\bar{1}13]$
D. $[\bar{1}\,\bar{1}3]$



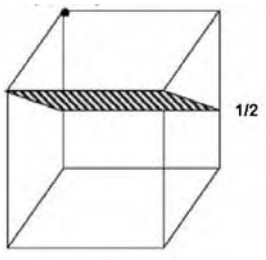
__A_ 19. The miller indices for the indicated crystallographic plane is

A. (212)
B. (221)
C. (122)
D. $(2\bar{1}2)$



____ 20. The miller indices for the shaded plane is

A. $(10\bar{2})$
B. $(1\bar{1}0)$
C. (210)
D. (102)



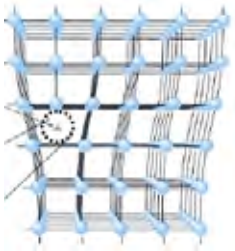
____ 21. Iron forms a bcc structure and its atomic radius is 0.124 nm. Its lattice constant is
A. 0.248 nm B. 0.496 nm C. 0.286 nm D. 0.124 nm

____ 22. The atomic packing factor of a bcc metal is
A. 0.74 B. 0.68 C. 055

____ 23. Gold has an fcc structure with an lattice constant of 0.40788 nm, the radius of gold is
A. 0.40788 nm B. 0.20394 nm C. 0.14421 nm D. 0.17662 nm

____ 24. The figure below is a(n)

A. vacancy
B. vacancy and interstitial atom
C. edge dislocation
D. screw dislocation



____ 25. Grain boundaries are:
A. point defects
B. line defects
C. two dimensional defects
D. none of the above

____ 26. Dislocations are:
A. point defects
B. line defects
C. two dimensional defects
D. none of the above

____ 27. Orientation of the Burgers vector of an edge dislocation to the dislocation line is
A. perpendicular
B. parallel
C. both a and b

____ 28. Two types of dislocations are:

A. interstitial and subsitutional
B. FCC and BCC
C. Edge and screw
D. None of the above

____ 29. The substitutional diffusion of Ni (solute) in Cu (solvent)
A. is a thermally activated process (improves with temperature)
B. increases in rate with increasing temperature
C. requires the presence of vacancies
D. all of the above

____ 30. During a steady state diffusion,
A. the concentration behavior does not change with time
B. the concentration behavior changes with time
C. the diffusion process can be described by Fick's First Law
D. both A and C

❖ **For the following 2 problems.** A foil 0.01 mm thick of iron separates gases containing 2.5×10^{22} and 8×10^{20} atoms of carbon per cubic centimeter. The diffusion coefficient of carbon in iron has constants of Q=142 kJ/mol and $D_o=2x10^{-5}$ m^2/s and R = 8.314 J/(mol•K) at a temperature of 927°C.

____ 31. The diffusion coefficient of carbon in iron (D in m^2/s) at 927°C is:

A. 1.32×10^{-11} m^2/s
B. 3.2×10^{-12} m^2/s
C. 0.63×10^{-10} m^2/s
D. 0.5×10^{-14} m^2/S

____ 32. The flux of carbon through the foil at this temperature is:

A. 6.3×10^{17} atom/(m^2.s)
B. 3.2×10^{14} atom/(m^2.s)
C. 0.4×10^{16} atom/(m^2.s)
D. 3.2×10^{16} atom/(m^2.s)

____ 33. If E_V is the formation energy of a vacancy, concentration of vacancies in metals as a function of temperature increases as

A. $\exp(-E_V/kT)$ B. $\exp(E_V/kT)$ C. E_V/kT

____ 34. For pure Cu at 500°, the activation energy for the formation of a vacancy is 0.90 eV. The Boltzmann's constant is $k = 8.62 \times 10^{-5}$ eV/K. $C_v = \exp(-E_v/kT)$ The vacancy concentration is:

A. 1.36×10^{-6} B. 1.36×10^{6} C. 1.36×10^{-12}

____ 35. Calculate the diffusivity of carbon in iron at 927℃. $D_0 = 2.0 \times 10^{-5}$ m^2/s, Q = 142 kJ/mol, R = 8.314 J/(mol·K)

A. 1.32×10^{-18} m^2/s
B. 1.32×10^{-11} m^2/s
C. 2.32×10^{-11} m^2/s

Constants and Equations for Exam #1

$N_A = 6.02 \times 10^{23}\ mole^{-1}$ $k = 8.62 \times 10^{-5}$ eV/atom- $R = 8.31$ J/mol-K

$1GPa = 10^3 MPa = 10^9 Pa = 10^9 N/m^2$ $1\ J/m^2 = 1\ N/m$ $K = C + 273$

10^9 nm = 1 m 10^2 cm = 1 m Volume of sphere $= \frac{4}{3}\pi R^3$

$$a_o = \frac{4R}{\sqrt{3}} \qquad a_o = \frac{4R}{\sqrt{2}} = 2R\sqrt{2} \qquad N_v = Ne^{-Q_v / kT}$$

$$J = -D\frac{dC}{dx} \qquad D = D_o \exp\left(\frac{-Q_d}{RT}\right) \qquad \frac{C_x - C_o}{C_s - C_o} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right)$$

Error function:

z	erf(z)	z	erf(z)	z	erf(z)	z	erf(z)
0.20	0.2227	0.55	0.5633	0.90	0.7970	1.50	0.9661
0.25	0.2763	0.60	0.6039	0.95	0.8209	1.60	0.9763
0.30	0.3286	0.65	0.6420	1.00	0.8427	1.70	0.9838
0.35	0.3794	0.70	0.6778	1.10	0.8802	1.80	0.9891
0.40	0.4284	0.75	0.7712	1.20	0.9103	1.90	0.9928
0.45	0.4755	0.80	0.7421	1.30	0.9340	2.00	0.9953
0.50	0.5205	0.85	0.7707	1.40	0.9523	2.20	0.9981

Answer key: 1B,2A,3B,4B,5A,6A,7C,8C,9C,10B,11C,12C,13C,14D,15B,16C,17D,18D,19A,20A
21C,22B,23C,24C,25C,26B,27A,28C,29D,30D,31A,32B,33A,34A,35B