Concordia University
Engineering and Computer Science

A

Department of Mechanical Industrial & Aerospace Engineering

MECH 221 – Midterm 2017
Multiple Choice – True/False Answer Sheet

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Name:
Student Number:

Detach this sheet from the answer book to make your task easier but **ensure that your name and student ID number are on this page as well as on your exam paper. Fill in the box containing your answer.**

Q					
1	a	b	c	d	e
2	a	b	c	d	e
3	a	b	c	d	e
4	a	b	c	d	e
5	a	b	c	d	e
6	a	b	c	d	e
7	a	b	c	d	e
8	a	b	c	d	e
9	a	b	c	d	e
10	a	b	c	d	e
11	a	b	c	d	e
12	a	b	c	d	e
13	a	b	c	d	e
14	a	b	c	d	e
15	a	b	c	d	e
16	a	b	c	d	e
17	a	b	c	d	e
18	a	b	c	d	e
19	a	b	c	d	e
20	a	b	c	d	e

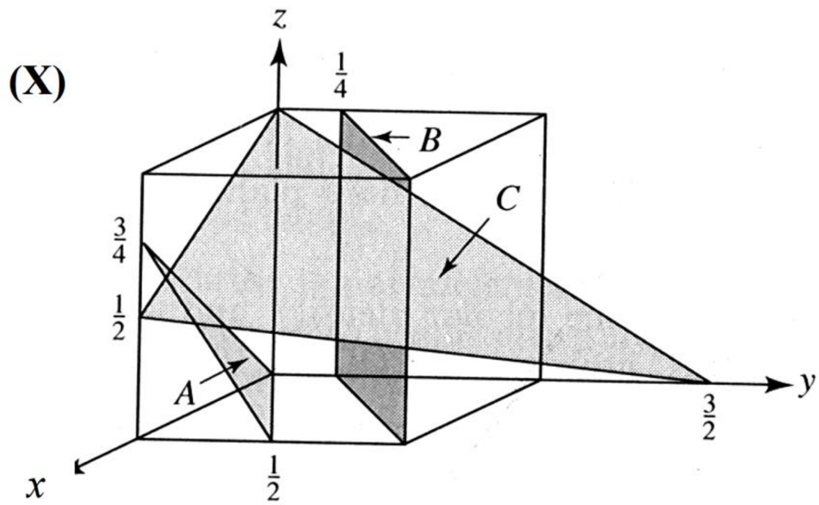
Q		
21	T	F
22	T	F
23	T	F
24	T	F
25	T	F
26	T	F
27	T	F
28	T	F
29	T	F
30	T	F
31	T	F
32	T	F
33	T	F
34	T	F
35	T	F
36	T	F
37	T	F
38	T	F
39	T	F
40	T	F

This page may be detached from the Exam booklet to aid completion.
Fill in your name and ID number above.

Name:	Student Number:

<u>Multiple Choice:</u> Select the best answer [*40 marks*]

1. In the adjacent Figure X, what are the coordinates of plane A?
   a) <**111**>
   b) $(\bar{4}23)$
   c) (423)
   d) $(\bar{3}64)$
   e) $(\bar{1}20)$



2. In the adjacent Figure X, what are the coordinates of plane B?
   a) (140)
   b) $(3\bar{4}0)$
   c) (14∞)
   d) $(\bar{1}20)$
   e) (340)

3. In the adjacent Figure X, what are the coordinates of plane C?
   a) (346)
   b) $(3\bar{4}6)$
   c) (223)
   d) $(\bar{1}23)$
   e) impossible to determine as this plane extends outside of the unit cell.

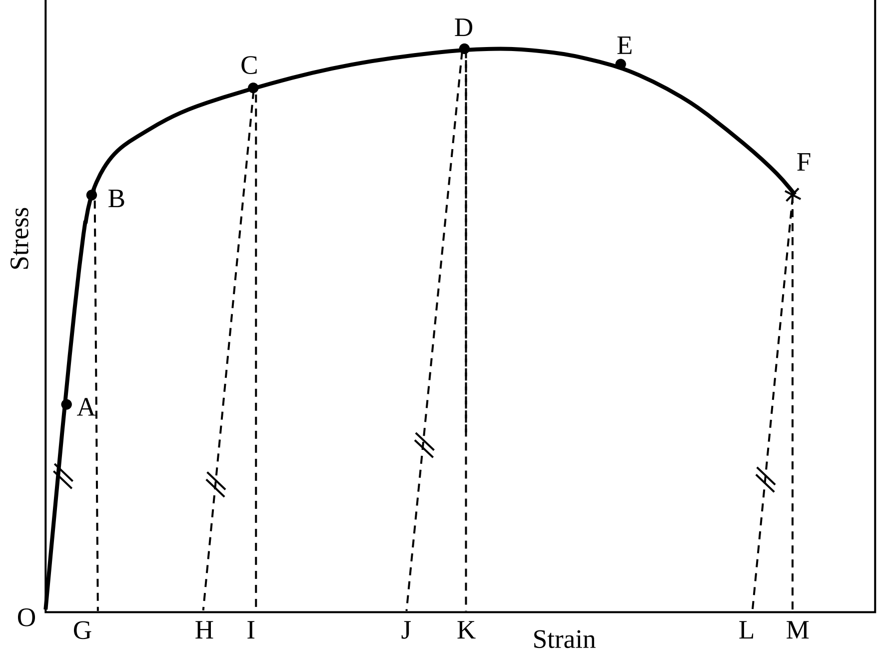
4. The linear atomic density for the [110] directions in BCC tungsten which has a lattice constant of 0.3165nm is:
   a) 2.2341×10^{9} m^{-1}
   b) 3.15×10^{9} m^{-1}
   c) 3.15×10^{7} m^{-1}
   d) 3.6483×10^{9} m^{-1}
   e) 1.322×10^{9} m^{-1}

5. With regard to diffusion:
   a) Diffusion is a time dependent process.
   b) Diffusion is a temperature dependant process.
   c) Diffusion occurs down a concentration gradient.
   d) Answers (a) and (b) only.
   e) Answers (a), (b), and (c).

6. If a smooth block of copper is pressed against a smooth block of nickel and both are heated to a high temperature (but below their melting points), and held for a long time:
   a) Copper atoms will diffuse into nickel because copper has the lower melting point.
   b) Nickel atoms will diffuse into copper because copper has the lower melting point.
   c) Copper atoms will diffuse into the nickel and nickel atoms will diffuse into the copper.
   d) No diffusion will occur between these metals because they have complete solid solubility in each other.
   e) Nickel will diffuse into copper because copper has a lower packing factor and more empty space available for the nickel atoms.

7. In Figure 1, Point B indicates the metal's:
   a) yield strength
   b) tensile strength
   c) toughness
   d) stiffness
   e) modulus of resilience

Figure 1: Stress vs strain curve for metal X



8. In Figure 1, Point D indicates the metal's:
   a) yield strength
   b) tensile strength
   c) toughness
   d) stiffness
   e) modulus of resilience

9. In Figure 1, the slope of the curve at Point A indicates the metal's:
   a) yield strength
   b) tensile strength
   c) toughness
   d) stiffness
   e) modulus of resilience

10. In Figure 1, Point L indicates the:
   a) elastic strain at the onset of necking
   b) plastic strain at the onset of necking
   c) elastic strain at fracture
   d) plastic strain at fracture
   e) total strain at fracture

11. In Figure 1, at Point C the metal has:
   a) stretched elastically and will return to its original length, O, when the load is removed.
   b) stretched elastically and plastically and will return to its original length, O, when the load is removed
   c) stretched elastically and will have a permanent strain, I, when the load is removed
   d) stretched elastically and plastically and will have a permanent strain, I, when the load is removed
   e) stretched elastically and plastically and will have a permanent strain, H, when the load is removed

12. In Figure 1, the metal begins to neck at Point:
   a) B
   b) C
   c) D
   d) E
   e) F

13. In Figure 1, there is <u>uniform</u> plastic deformation at the following Point(s):
    a) B
    b) C
    c) D and E
    d) E
    e) F

14. In Figure 1, there is <u>non-uniform</u> plastic deformation at the following Point(s):
    a) B
    b) C
    c) C and D
    d) D, E and F
    e) F only

15. In Figure 1, the Modulus of Resilience can be approximated by the area bounded by the Points:
    a) OAG
    b) OBG
    c) OBDJ
    d) OBDK
    e) OBFM

16. In Figure 1, the toughness can be approximated by the area bounded by the Points:
    a) OBG
    b) OCI
    c) OBDJ
    d) OBDK
    e) OBFM

17. Which of the following statements regarding atomic bonding is correct?
    (a) The three atomic primary bonds are ionic bonds, metallic bonds and Van der Waals forces.
    (b) Intermolecular bonds are usually stronger than atomic bonds.
    (c) Metallic bonds are the result of attraction of ions of opposite charge.
    (d) Atoms are subjected to attraction and repulsion forces between them and the lowest potential energy occurs when these forces cancel each other.
    (e) For ionic bonding, the coordination is small because only positive and negative ions are in contact.

18. A tensile specimen with a 50mm gauge length and 12mm diameter was fractured in a tensile test. After fracture the gauge length became 68mm and the neck was 6.4mm in diameter. Which of the following values are correct?
    a) 26.5% elongation and 87.5% reduction in area
    b) 18% elongation and 32.2% reduction in area
    c) 18% elongation and 46.7% reduction in area
    d) 36% elongation and 46.7% reduction in area
    e) 36% elongation and 71.6% reduction in area

19. A cylindrical rod of copper (E = 110 GPa) having a yield strength of 240 MPa is to be subjected to a load of 6660 N. If the length of the rod is 380 mm, what must be the diameter to allow an elongation of 0.50mm?
    a) 7.65 mm
    b) 76.5mm
    c) 1.92mm
    d) 15.3mm
    e) The stress strain diagram of copper is needed to solve this question

20. Crystals can contain a variety of defects: examples of 1) Point; 2) Linear; 3) Planar/Area defects are respectively:
    a) Grain boundaries: vacancy: crystal
    b) Substitutional atom: vacancy: dislocation
    c) Vacancy: linear density: planar density
    d) Dislocation: substitutional atom: vacancy:
    e) Vacancy: dislocation: grain boundary

True or False: Decide whether the following statements are True or False and shade in the appropriate box on the Answer sheet. [*20 marks*]

21. Dislocations move most easily in a crystal along the highest density planes in the lowest density direction.

22. The [111] direction in the FCC unit cell is parallel to the (111) plane.

23. The valence electrons in a carbon atom can form four sp3 hybrid orbitals which form four directional ionic bonds.

24. The rate of diffusion in materials depends on their state: diffusion is fastest in the gaseous state, intermediate in the liquid state and slowest in the slid state all other factors being equal.

25. The Atomic Packing Factor (APF) in the FCC system is 0.74 whereas in BCC it is lower, at 0.68.

26. Solid state diffusion of atoms requires the following: an adjacent vacant site and sufficient energy to move the atom.

27. Movement of dislocations in crystals by slip occurs in metallically and ionically bonded materials relatively easily at room temperature but they cannot move in covalently bonded materials due to the strong directionality of the bonds.

28. {100} represents the family of planes that make up the sides of the cube of the BCC unit cell and for the FCC unit cell it is the {110} family of planes.

29. For a material where D_o = l.6 x $l0^{-4}$ m^2/s and Q_d = l8l kJ.mol^{-1} the diffusion coefficient at 1200ºC is 8.4x 10^{-7} m^2 s^{-1}.

30. Copper, (which is FCC, and has an atomic mass of 63.5 g/mol and an atomic radius of = 0.128 nm) has a theoretical crystal density of 8.89 Mgm-3.

31. FCC metals and BCC metals are generally ductile because they have sufficient number of good slip systems (slip directions and slip planes) whereas HCP metals are generally more brittle as they have fewer independent slip systems and slip is more difficult.

32. Electron microscopes probe microstructures with greater resolution and magnification than optical microscopes.

33. Etching is used only to reveal the microstructure of amorphous materials.

34. During a tensile test, engineering stress will always have an equal or higher value than true stress.

35. In an alloy, the material that dissolves the alloying element is called the unit cell.

36. A metallic solid solution is composed of two phases: the solute and the precipitate.

37. Generally, weakly bonded solids have low melting point, low elastic modulus, and high thermal expansion coefficient.

38. When molten metals are solidified (frozen) into crystalline solids they do not contain any vacancies or dislocations: these defects are created when the solid metal is plastically deformed.

39. As temperature decreases, the fraction of the total number of atoms that are capable of diffusive motion decreases.

40. The coordination number for the hexagonal close-packed structure is 12.

Mech 221 Formulae

$$A \cong Z + N$$

$$F_N = F_A + F_R$$

$$E = \int F dr$$

$$E_N = \int_{\infty}^{r} F_N dr = E_A + E_R$$

% ionicity = {1-exp[-(0.25)(X_A-X_B)^2]}x100

$$a = 2R\sqrt{2}$$

$$a = \frac{4R}{\sqrt{3}}$$

$$APF = \frac{\text{volume of atoms in a unit cell}}{\text{total unit cell volume}}$$

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

$$N_v = N \exp\left(-\frac{Q_v}{kT}\right) \qquad J = -D\frac{dC}{dx} \qquad \frac{\partial C}{\partial t} = D\frac{\partial^2 C}{\partial x^2}$$

$$LD = \frac{n_a}{L_l}$$

$$D = D_o \exp\left(\frac{-Q}{RT}\right) \qquad \frac{C_x - C_0}{C_s - C_0} = 1 - erf\left(\frac{x}{2\sqrt{Dt}}\right) \qquad \sigma = E\varepsilon$$

$$PD = \frac{n_a}{A_p}$$

$$n\lambda = 2d_{hkl}\sin\theta$$

$$\varepsilon_{eng} = \left(\frac{l_i - l_o}{l_o}\right) = \frac{\Delta l}{l_o} \qquad \%El = \left(\frac{l_i - l_o}{l_o}\right)x100 \qquad \nu = -\frac{\varepsilon_x}{\varepsilon_z} = -\frac{\varepsilon_y}{\varepsilon_z}$$

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$

$$\%RA = \left(\frac{A_0 - A_f}{A_o}\right)x100 \qquad U_r = \frac{1}{2}\sigma_y \varepsilon_y = \frac{\sigma_y^2}{2E}$$

Constants

N_A = 6.023 x 10^{23} atoms/mol
k = 8.62 x 10^{-5} eV/atom-K or 1.38 x 10^{-23} J/atoms-K
R = 8.314 J/mol-K

z	erf(z)	z	erf(z)	z	erf(z)
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.00	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999