

# Assignment 5

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- 1) Match the techniques listed in Column I with the characteristics of the materials measured in Column II.

Column I	Column II
P. DSC	1. Density of states
Q. XRD	2. Glass transition temperature
R. STM	3. Cathodoluminescence
S. SEM	4. Crystal structure
	5. Thermal expansion coefficient

(XE 2015)

- a) P-2, Q-3, R-4, S-1                      c) P-2, Q-4, R-1, S-3  
b) P-5, Q-4, R-5, S-1                      d) P-3, Q-5, R-4, S-2

- 2) The mass of an electron would increase \_\_\_\_\_ times its original mass if it travels at 96% of the speed of light.

(XE 2015)

- 3) With increasing temperature from  $15^{\circ}\text{C}$  in winter to  $40^{\circ}\text{C}$  in summer, the length of an iron rail track increases by  $0.05\text{ cm}$ . Calculate the original length of the iron rail track in cm.  
(linear thermal expansion coefficient of iron is  $11.0 \times 10^{-6}\text{ K}^{-1}$ )

(XE 2015)

- 4) What is the thickness (in  $\mu\text{m}$ ) of a germanium crystal layer that would be required for absorbing 80% of the incident radiation whose wavelength is  $1.3\mu\text{m}$ ? The absorption coefficient ( $\alpha$ ) of germanium at  $1.3\mu\text{m}$  is  $3.3 \times 10^5\text{ m}^{-1}$

(XE 2015)

- 5) A  $1\text{ kg}$  sacrificial anode of  $\text{Mg}$  (atomic weight:  $24.31\text{ amu}$ ) is attached to the base of a ship. If the anode lasts for 60 days, what is the average corrosion current (in Amperes) during that period?

(XE 2015)

- 6) A capacitor has a  $0.075\text{ cm}$  thick  $\text{BaTiO}_3$  dielectric with a dielectric constant of 2000 and an electrode area of  $0.2\text{ cm}^2$ . What is the capacitance of this capacitor in  $\text{nF}$ ?

(XE 2015)

- 7) A hot pressed ceramic composite material consists of 30 volume %  $\text{SiC}$  whiskers in an  $\text{Al}_2\text{O}_3$  matrix. The measured bulk density of this composite is  $3.65\text{ g cm}^{-3}$ , estimate the porosity (%) of the composite, assuming that the linear rule of mixtures is valid in this case.

(XE 2015)

- 8) Match the technical ceramics listed in Column I with their common applications listed in Column II

(XE 2015)

Column I	Column II
P. Y-doped $ZrO_2$	1. Lasers
Q. $UO_2$	2. Turbine Engine
R. $Si_3N_4$	3. Integrated circuit substrate
S. $AlN$	4. Oxygen sensor
T. Cr doped $Al_2O_3$	5. Nuclear fuel
	6. Thermistor

a) P-6, Q-4, R-5, S-1, T-3

c) P-3, Q-1, R-2, S-6, T-5

b) P-4, Q-5, R-2, S-3, T-1

d) P-1, Q-4, R-5, S-2, T-1

9) Creep in metals is defined as

(XE 2015)

a) the maximum energy a solid can absorb elastically

b) the maximum energy a solid can absorb by plastic deformation

c) the stress at which plastic deformation starts

d) slow plastic deformation due to diffusion of atoms usually at high temperatures ( $T >$  half the melting point)

10) Calculate the planar density of the (100) plane in an fcc crystal given that  $R$  is the atomic radius of the element.

(XE 2015)

a)  $0.25R^2$

b)  $\frac{0.25}{R^2}$

c)  $\frac{1}{R^2}$

d)  $\frac{4}{R^2}$

11) The diffusion coefficient of copper atoms in aluminium is found to be  $1.28 \times 10^{-22} \text{ m}^2 \text{ s}^{-1}$  at  $T = 400 \text{ K}$  and  $5.75 \times 10^{-19} \text{ m}^2 \text{ s}^{-1}$  at  $T = 500 \text{ K}$ . Find the temperature (in Kelvin) at which the value of the diffusion coefficient is  $10^{-16} \text{ m}^2 \text{ s}^{-1}$

(XE 2015)

12) Calculate the density of copper in  $\text{kgm}^{-3}$  given that copper has an fcc lattice with a lattice parameter of  $0.365 \text{ nm}$ . Copper has an atomic weight of  $63.54 \text{ amu}$ .

(XE 2015)

13) What would be the maximum number of electron-hole pairs that can be generated using a silicon detector irradiated by X-ray of energy  $1.54 \text{ keV}$ . The band gap of silicon is  $1.1 \text{ eV}$ .

(XE 2015)