UNIVERSITY OF PETROLEUM & ENERGY STUDIES

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End Semester Examination – May, 2018

Program/course: M.Tech. (Nuclear Science and Technology)	**Semester – II**
Subject: Nuclear Engineering Materials	**Max. Marks : 100**
Code: NSAT7008	**Duration : 3 Hrs**
No. of page/s: 2	

Section –A
Note: All questions are compulsory.

Q1. Define slip systems in crystals. Is it possible to decide whether a material is ductile or brittle based on the number of slip systems it has? [**5**]

Q2. What is plenum region in nuclear fuel rods? Discuss its significance in ensuring the integrity of fuel elements during nuclear fission. [**5**]

Q3: Why bulk diffusion is slower as compared to grain boundary and surface diffusion? Will the same scenario prevail at very high temperatures also ($T < T_m$, where T_m is melting temperature)? [**5**]

Q4: Describe the motion of screw dislocations under applied external stress. How is it different from the conservative motion of edge dislocations (be brief in your explanation)? [**5**]

Section – B
Questions 5-8 are compulsory. Question 9 has an internal choice

Q5. Discuss the lattice structure of UO_2. Explain by considering the occupancy of different sublattices in UO_2. [**5**]

Q6. Derive an expression of the force on a dislocation moving under the action of uniform resolved shear stress τ. If the material is not under an externally imposed stress, will there still be a force on the dislocation? Discuss. [**5**]

Q7: Explain following in brief: [**5×2=10**]

I) Mechanism of cross-slip in FCC solids.

II) Diffusion and Coble Creep

Q8. Derive an expression for temperature distribution in a fuel under burn up, considering that the amount of heat generated is transported away (no heat accumulation). Also, consider that the thermal conductivity of the fuel is constant (which is, although, a very crude assumption).
[**10**]

Q9a. Explain Peierls-Nabarro (P-N) stress in crystals. Based on the value of P-N stress is it possible to know whether a material is a metal or ceramic? [**10**]

OR

Q9b. Write short notes on the following mechanisms: [**10**]

a) Dependence of thermal conductivity of UO_2 on stoichiometry & porosity
b) Single and double stacking faults

Section –C
Q10 is compulsory. Question 11 has an internal choice.

Q10: Discuss the dependence of specific heat of various materials on temperature which has been observed experimentally. Explain how Einstein modeled this dependence, which was later modified by Debye. What were shortcomings in Einstein's model which were taken care of by Debye? [**20**]

Q11a: Derive Orowan's equation relating the rate of deformation of a material in terms of various microscopic parameters like dislocation density, average dislocation velocity, Burgers vector, etc. Does dislocation velocity depend upon the applied shear stress? If yes, explain the dependence. [**20**]

OR

Q11b: Show that the elastic strain energy due to a screw dislocation of burgers vector $\vec{b}$ in a material is given as:

$$E_{el}(screw) = \frac{G b^2}{4\pi} \ln\left(\frac{R}{r_0}\right)$$

where G is shear modulus, b is burgers vector, R is the outer radius and r_0 is the inner radius of the cylinder representing screw dislocation.

If two such screw dislocations of burgers vectors $\vec{b}_1$ and $\vec{b}_2$ are lying near to each other, discus the conditions of their interactions to make another dislocation of burgers vector say $\vec{b}_f$. [**20**]