

# Unit 13 - Week 11

**Course outline**

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## Assignment 11

The due date for submitting this assignment has passed. **Due on 2019-10-16, 23:59 IST.**  
 As per our records you have not submitted this assignment.

- 1) Determine the correctness(or otherwise) of the statement. **1 point**  
**Assertion(A):** When the actual temperature gradient is lower than the critical temperature gradient at the interface, the curved solidification front is stable.  
**Reason(R):** For the curved interface to be stable, the temperature ahead of the interface should be less than the liquidus temperature
- Both A and R are true but R is NOT the correct explanation of A  
 Both A and R are true and R is the correct explanation of A  
 A is false but R is true.  
 Both A and R are false.
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 Both A and R are true and R is the correct explanation of A
- 2) A species can diffuse through the lattice (diffusion coefficient,  $D_L$ ), along grain boundaries (diffusion coefficient,  $D_{GB}$ ), and along free surfaces (diffusion coefficient,  $D_S$ ). Which of the following relations **1 point**
- $D_L > D_{GB} > D_S$   
  $D_S > D_L > D_{GB}$   
  $D_{GB} > D_S > D_L$   
  $D_S > D_{GB} > D_L$
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 $D_S > D_{GB} > D_L$
- 3) If  $\Delta x$  represents adherent oxide layer thickness and  $t$  is time, which of the following curves represents diffusion-controlled oxidation kinetics? **1 point**

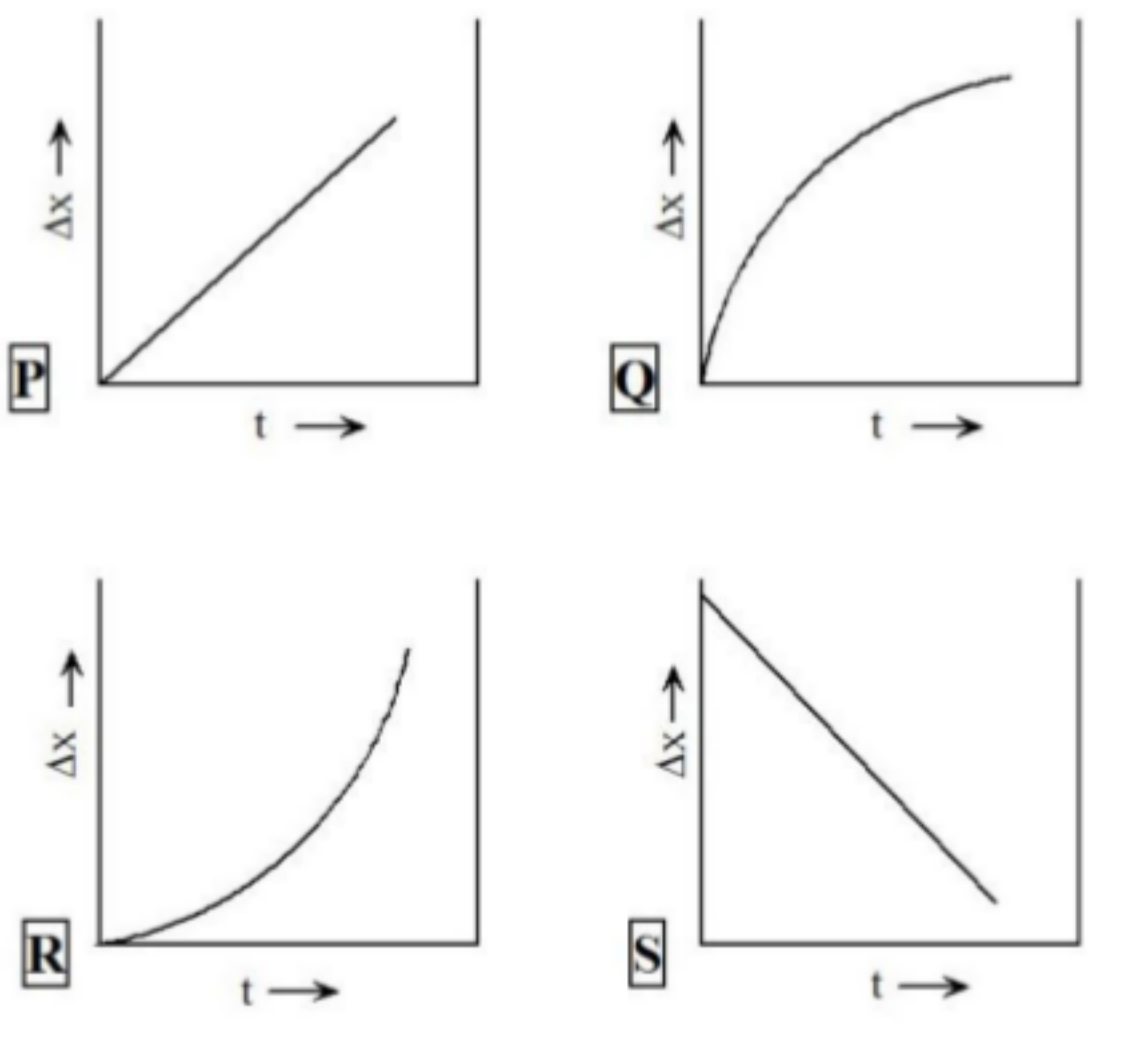


Figure 1: Diffusion controlled oxidation kinetics

- P  
 Q  
 R  
 S
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 Q
- 4) It takes 10 hours to homogenize an alloy at 1273 K. The time required (in hours) to achieve the same extent of homogenization at 1373 K is  
 Given: Diffusivity,  $D_{1273} = 10^{-18} m^2/s$  and  $D_{1373} = 10^{-19} m^2/s$
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 0.9,1.1
- 1 point**
- 5) In vacuum degassing of steel, 14 ppm of dissolved nitrogen is in equilibrium with 1 mbar of nitrogen gas at 1873 K. At the same temperature, if the pressure is lowered to 0.7 mbar, the equilibrium nitrogen content (in ppm) is.....
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 11.6,11.8
- 1 point**
- 6) Hydrogen dissolves in Pd by the reaction  $H_2 = 2[H]$ . At  $300^\circ C$  and  $P_{H_2} = 1$  atm, the solubility of hydrogen in Pd is  $1.64 \times 10^4 mm^3(STP)$  per kg of Pd. At  $300^\circ C$  and  $P_{H_2} = 0.09$  atm, the solubility of hydrogen in Pd is in  $mm^3(STP)$  per kg of Pd is (answer up to one decimal place)..
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 4900,4940
- 1 point**
- 7) During the end blow period in LD steel making, the de-carburization rate is expressed by the equation:  $\frac{dc}{dt} = -(c - c^*)$ . Here  $c$  and  $c^*$  are instantaneous and equilibrium concentration of carbon in steel respectively in wt%. Time is given in minutes. Given that  $c^* = 0.04$  wt% and  $c(t = 0 \text{ min}) = 0.4$  wt%, the concentration of steel (in wt%) at  $t = 1$  min is....(answer up to 3 decimal places)
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 0.170,0.175
- 1 point**
- 8) Estimate the ratio of permeability of hydrogen gas in copper at  $727^\circ C$  and  $627^\circ C$ . Given that  $\Pi_0 = 2 \times 10^{-4} cm^3(STP)s^{-1}cm^{-1}atm^{-1/2}$  and  $Q = 17,000 cal/mol$ . (answer upto 2 decimal places). Consider the value of  $R$  as  $2 cal/mol/K$ .
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 2.4,2.6
- 1 point**
- 9) Hydrogen is expected to be fuel for automobiles in near future. Thus, it is necessary to build tanks to store high pressure hydrogen gas. As an engineer, you need to take care of the strength of the structural material as well as functional property of avoiding leakage of gas. Which of the following materials is the most appropriate choice to store hydrogen gas?
- Given  $\frac{\Pi_{H_2-Cu}}{\Pi_{H_2-Fe}} = 10^{-5}$  at the temperature of interest
- Copper cylinder coated with steel on the inside  
 Steel cylinder coated with Cu on the inside  
 Steel cylinder coated with Cu on the outside  
 Steel cylinder
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 Steel cylinder coated with Cu on the inside
- 1 point**
- 10) The grain boundary diffusion and bulk diffusion are schematically represented as 2 lines in  $\log D$  vs  $1/T$  plot. Which line possibly represents the grain boundary diffusion?

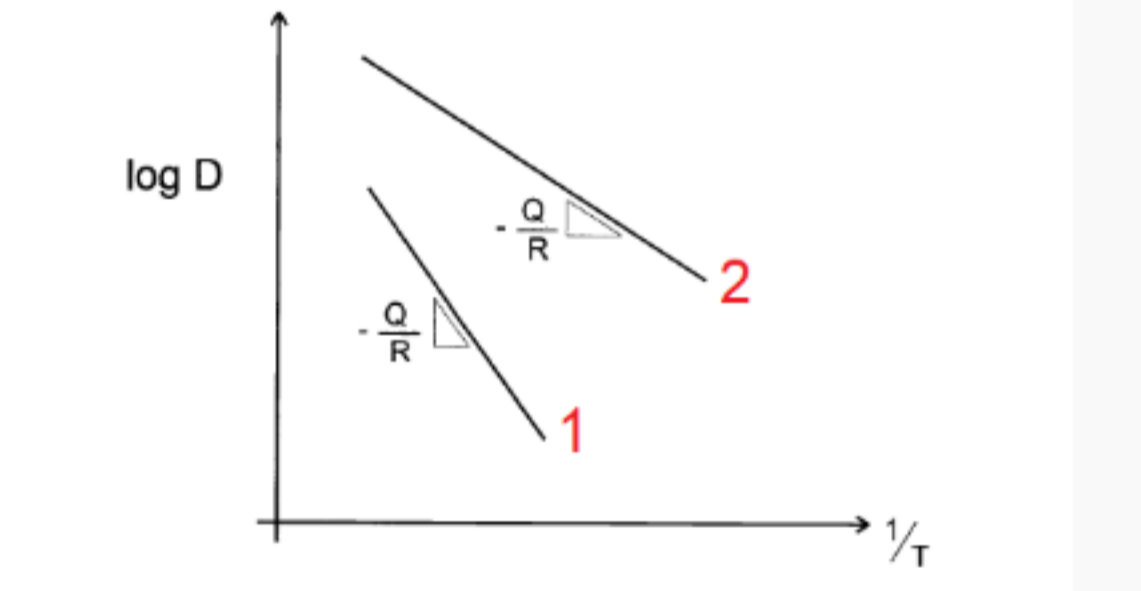


Figure 2: Grain boundary and bulk diffusion

- Line 1  
 Line 2  
 Both the Lines  
 Insufficient data
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 Line 2
- 1 point**
- 11) Determine the correctness(or otherwise) of the statement. **1 point**  
**Assertion(A):** Diffusion is faster in cold rolled aluminium than as-cast aluminium  
**Reason(R):** Cold rolling results in elongated grains.
- Both A and R are true and R is the correct explanation of A.  
 Both A and R are true but R is NOT the correct explanation of A.  
 A is false but R is true.  
 Both A and R are false.
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 Both A and R are true but R is NOT the correct explanation of A.
- 12) Both sides of a 2mm thick steel sheet are exposed to nitrogen. When the pressure at both sides are 0.2 MPa and 50 MPa, find the flux of nitrogen diffusing in the steel sheet at  $500^\circ C$  **1 point**  
 Given that  $\Pi_0 = 4.5 \times 10^{-3} cm^3(STP)s^{-1}cm^{-1}atm^{-1/2}$  and  $Q = 23,800 cal/mol$ . Consider the value of  $R$  to be  $2 cal/mol/K$ .
- $2.77 \times 10^{-8} cm^3/g$   
  $8.72 \times 10^{-9} cm^3/g$   
  $8.72 \times 10^{-8} cm^3/g$   
  $11.5 \times 10^{-3} cm^3/g$
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 $8.72 \times 10^{-8} cm^3/g$
- 13) After exposure to carburizing atmosphere, the carbon concentrations at the two surfaces of a 3mm thick steel sheet were determined to be 2.5 and 0.71 wt%. Assuming steady state diffusion, estimate the diffusion coefficient of carbon in steel (in terms of  $10^{-12} m^2 s^{-1}$ ) answer upto 1 decimal place. Given that diffusion flux is  $7.8 \times 10^{-9} kg m^{-2} s^{-1}$ ,  $\rho_C = 2.25 g/cc$  and  $\rho_{Fe} = 7.86 g/cc$
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 16,19
- 1 point**
- 14) It is found that the diffusion coefficient of carbon in  $\gamma$  iron at 1100K is 40 times that at 900K. Estimate the activation energy in kJ/mol. Take the value of  $R$  to be  $8.314 J/mol/K$ . Answer corrected up to one decimal point
- 
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 (Type: Range) 150,153
- 1 point**
- 15) If the liquidus and solidus temperatures of an alloy are  $660^\circ C$  and  $650^\circ C$  respectively and the velocity of the solidification front is  $5 \mu m/s$ , find the temperature gradient (K/mm) above which the planar solidification front is possible. Given that diffusion coefficient  $D = 3 \times 10^{-9} m^2/s$
- 6  
 15  
 16.7  
 33.3
- No, the answer is incorrect.**  
 Score: 0  
**Accepted Answers:**  
 16.7