Ref. No.: Ex/PG/MET/PC/T/112/2025

M.TECH Material Engineering - First Year -1st Semester Examination 2025

Subject: Physicochemical Processing of Materials

Time: Three Hours **Full marks:** 100

(Answer Q1 or Q2; Q3 or Q4; Q5 or Q6; Q7 or Q8 and Q9 OR Q10)

Q1. (a) Define different heat capacities of a substance? How are these heat capacities mathematically expressed? Why does one form of heat capacity higher? **[CO I]** 6+2+2 = 10

(b) Derive the relationship between different heat capacities, and from this derived relationship find the relationship between the heat capacities for 1 mole ideal gaseous system. **[CO I]** 6+4 = 10

Q2. (a) How is 'enthalpy' of a system defined? Show that the change in enthalpy of a system between two different states is related with heat energy involved. **[CO I]** 3+4 = 7

(b) Show that in case of an ideal gas 'enthalpy' is independent of temperature at constant pressure. **[CO I]** 6

(c) Calculate the difference between ΔH and ΔU per mole of the following reaction at 500 °C and 1 atmos. pressure: **[COI]** 7

$$2H_2\,(g) + O_2\,(g) = 2H_2O\,(g)$$ **[CO I]**

Q3. (a) Give a general flow sheet for extraction of metals following hydrometallurgical route. **[CO II]** 7

(b) Describe a scheme with relevant figure for leaching kinetics where solid residue is formed. **[CO II]** 6

(C) Derive the necessary relationship for leaching kinetics of gold in situation where the concentration of main leachant is very low. **[CO II]** 7

Q4. What is an 'ion exchange' process? What are different ion exchangers and do they serve? Discuss all the characteristics of an ion exchanger used for extraction of metals from a solution. How would you extract uranium from its ore following ion exchange process? **[CO II]** 4+4+6+6 = 20

Q5. (a) What is the difference between 'roasting' and 'calcination?' What is the importance of roasting operation in extraction of metals by hydrometallurgical processes? What is known as 'dead roasting?' Would you always recommend for 'dead roasting?' If not, give an example. **[CO III]** 5+3+2+1+1 = 12

(b) What is 'predominance area diagram and its importance? With an example briefly discuss the method of drawing a 'predominance area diagram'. **[CO III]** 4+4 = 8

Q6. (a) What is an Ellingham diagram? What is the basis on which Ellingham diagram is drawn? State the salient features of this diagram. With an example discuss the metallothermic reduction of oxide. **[CO III]** 4+2+3+6 = 15

(b) How does 'smelting' operation differ from melting? Write the general reaction that occurs during 'smelting.' **[CO III]** 3+2 = 5

Q7. (a) Find the oxygen partial pressure in equilibrium with a metal and its oxide at a given temperature and make comment about this metal to metal oxide reaction. **[CO III]** 4

(b) Would you recommend for carbothermic reduction of aluminium ore for extraction of aluminium? Give justification in support of your answer. Discuss the processing route followed for extraction of aluminium from its ore. **[CO III]** 4+12 = 16

[Turn over

Q8. (a) What is known as activity of a component in a solution? What will be the activity of component for a very dilute binary solution? State the law for knowing the activity of a component in a dilute binary solution. What will be the activity of the component when the solution is not so dilute?
[CO IV] 3+2+2+2 = 9

(b) Discuss Gibbs-Duhem Equation for a multicomponent solution. How would you obtain 'partial molar free energy' in case of a binary solution? **[CO IV]** 6+5 = 11

Q9. (a) What do you understand by the order of a reaction? Discuss the reaction rate in case of (i) First-Order reaction, (ii)Second-Order reaction, and Reactions close to equilibrium. **[CO V]** 3+9 = 12

(b) Discuss the effect of concentration and temperature on reaction rate. **[CO V]** 8

Q10. (a) With an example discuss the contact reduction process of metals in aqueous solutions and the kinetics involved in this process. **[CO V]** 5 + 8 = 13

(b) How would you ascertain the rate controlling step of a leaching process? Discuss. **[CO V]** 7