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May 2026

M. Sc. (Physics) (Fourth Semester)

ADVANCED MATERIALS SCIENCE

(PHP-222-V)

Time : 3 *Hours*] [*Maximum Marks* : 75

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other.

Part A

1. (a) Define Phase rule. 1.5

(b) Write the equation for Eutectic and Eutectoid cooling. 1.5

(c) Define coherence length in superconductors. 1.5

(d) Define Cooper pair in BCS theory. 1.5

(e) What are Whiskers ? 1.5

(f) What are Metal Matrix Composites (MMC) ? 1.5

(g) List any *two* characteristics of smart materials. 1.5

(h) Why Pb-Sn eutectic alloys are used for soldering purpose ? 1.5

(i) Define magnetoresistance effect. 1.5

(j) In a binary phase diagram (pressure omitted), what is the maximum number of phases that can co-exist for at least one degree of freedom ? 1.5

Part B

2. (a) What do you mean by lever rule ? Explain with the help of one example. 5

(b) State Home-Rothery rules that governs the formation of substitutional solid solution. 4

(c) Explain Gibb's phase rule. Determine the degree of freedom for an isomorphous alloy system when both the phases co-exist at equilibrium. 6

3. (a) The following data apply to the binary system of A and B : 8

Melting point of pure A = 1050°C

Melting point of pure B = 1900°C

At 1250°C, the α solid solution (containing 50% of B), the β solid solution (containing 80% of B) and liquid (containing 30% of B) are in three-phase equilibrium. At room temperature, the maximum solubility of B in the α phase is 30% and the maximum solubility of A in the β phase is 10%.

(i) Sketch the phase diagram of A and B, showing the phases present in each area of the diagram.

(ii) What is the reaction that takes place at 1250°C ?

(iii) What are the weight fractions of the phases present in a material of overall composition 75% B, at 1251°C, 1249°C and at room temperature (RT) ?

(b) Draw the binary phase diagram of Al_2O_3-Cr_2O_3. Explain it in detail. What do you mean by "1-2-1" rule in this diagram ? 7

4. (a) Explain flux quantization in a superconducting ring and derive the expression : 7

$$\Phi = nh/2e$$

(b) Explain single particle tunneling in superconductors. 4

(c) Discuss the qualitative features of BCS theory of superconductivity. 4

5. (a) Compare cermets and metal matrix composites in terms of structure, properties, and applications. 7

(b) Differentiate between flake composites, fiber composites and whisker composites. 8

6. (a) Describe fiber-reinforced glass and glass-ceramic composites. 5

(b) Explain the structure and applications of piezoelectric polymers. 5

(c) Explain the AC and DC Josephson effect. 5

7. (a) Discuss the structure, properties and applications of perovskite piezoceramic materials. 5

(b) Explain the difference between normal and giant magnetostriction. 5

(c) Describe wood composites, their types, manufacturing process and uses. 5

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