Name:

Enrolment No:

UPES
End Semester Examination, December 2023

Course: Aircraft Material **Semester :VII**
Program: B. Tech Aerospace **Time : 03 hrs.**
Course Code: ASEG4019P **Max. Marks: 100**
Instructions:

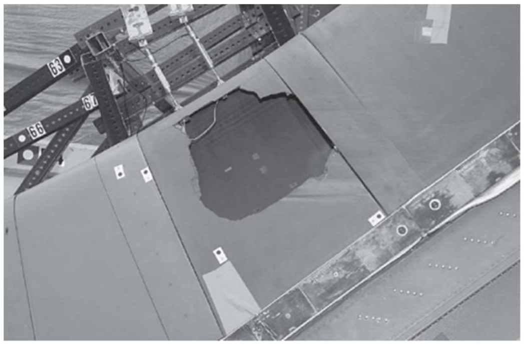
1. **The Question paper has three sections: Section A, B and C.**
2. **Section B and C have internal choices.**
3. **Assume suitable data if needed**

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	State the advantages and disadvantages of CMC.	**4**	**CO1**
2	Compare the following alloying elements based on mechanical property. a) Tungsten b) Chromium	**4**	**C02**
3	Describe the importance of high-temperature nickel alloys in flight structures.	**4**	**C01**
4	Classify the five generation of superalloy with suitable example.	**4**	**C01**
5	Show that the atomic packing factor for the FCC crystal structure is 0.74.	**4**	**C02**

SECTION B
(4Qx10M= 40 Marks)

6	Develop a case study comparing the use of traditional materials and advanced composites in aircraft manufacturing	**10**	**CO3**
7	Classify titanium and its alloys. Explain, the extraction, melting, welding and properties of titanium alloys.	**10**	**C02**
8	Discuss types of heat treatment process used for the following application in detail 1) Chisel used in carpentry operation 2) Wire drawing operation 3) Car Body 4) Propeller blade	**10**	**C02**
9	Explain the following manufacturing process with a suitable example. 1. Electrochemical machining 2. Electroplating OR	**10**	**C04**

	Investigate the reasons behind the use of specific materials in high-temperature areas of aircraft engines.		
SECTION-C **(2Qx20M=40 Marks)**			
10	Explain Inconel, Monal and K–Monal alloys, their properties and applications to aerospace vehicles.	**20**	**CO3**
11	One of the most high profile accidents involving fracture was the space shuttle Columbia disaster that occurred during re-entry into the Earth's atmosphere on February 1, 2003. The seven crew members of flight STS-107 were killed when Columbia broke up while travelling at about Mach 18.5 at an altitude of 64 km. Following an exhaustive investigation it was concluded that the loss of Columbia was the result of damage sustained to the thermal protection system. The leading edges of the space shuttle wings are covered with a brittle reinforced carbon–carbon composite to provide thermal protection to the underlying aluminum structure. During take-off a piece of foam insulation broke away from an external fuel tank. The foam, which was about the size of a small briefcase, smashed into the leading edge of the left-side wing of Columbia. The reinforced carbon–carbon composite, which is a brittle material with low fracture toughness, broke under the impact force. Tests performed as part of the accident investigation showed that the foam insulation could breach the thermal protection system, leaving a large hole that exposed the underlying aluminium structure (refer the figure). The extremely high temperatures experienced during re-entry caused the exposed aluminium structure to melt which subsequently caused Columbia to break up. The reinforced carbon–carbon material has low resistance against fracture because no plastic deformation occurs during crack growth. This accident tragically highlights the risk involved in using brittle materials, even in accidental load cases such as the foam impact on Columbia 18.5 at an altitude of 64 km.  Based on the above case study answer the following questions**.(4marks each)** 1. What was the cause of the Columbia space shuttle disaster, and how did it relate to the thermal protection system? 2. Can you elaborate on the role of the reinforced carbon–carbon composite in providing thermal protection to the space shuttle wings, and why is it considered a brittle material?	**20**	**C04**

3. How did the foam insulation, which broke away during take-off, lead to the damage of the thermal protection system, specifically the reinforced carbon–carbon composite on the left-side wing of Columbia?
4. What were the findings of the investigation regarding the impact of the foam insulation on the reinforced carbon–carbon composite, and how did this impact contribute to the subsequent failure during re-entry?
5. In what way did the properties of the reinforced carbon–carbon material, such as its low fracture toughness and lack of plastic deformation during crack growth, play a role in the catastrophic failure of the Columbia space shuttle?

Or

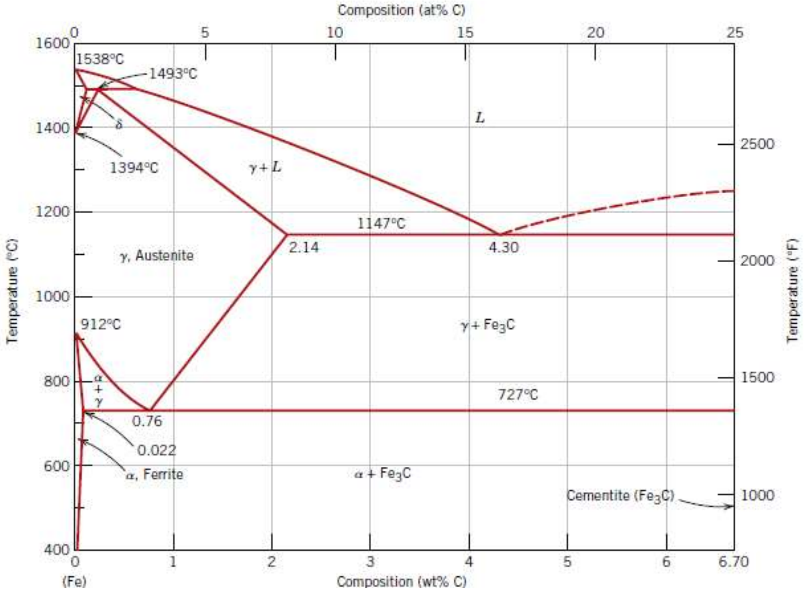
Analyze the Iron-Carbon phase diagram shown below and answer the following questions:

(i) Differentiate between different types of steels based on their carbon concentrations. Write the solubility of carbon in ferrite at 727°C.

(ii) Write eutectoid, eutectic and peritectic temperatures.

(iii) Write all the invariant reactions with their phase compositions.

(iv) Sketch and explain the microstructure evolution of eutectoid, hypo eutectoid and hypereutectoid steel.



Iron-carbon phase diagram