Name: **Enrolment No:**	UPES UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES
End Semester Examination, December 2021

Course: Nanomaterial Processing and Application **Semester: VII**
Program: B. Tech Mechanical **Time 03 hrs**
Course Code: MEMA4005P **Max. Marks: 100**

Instructions:

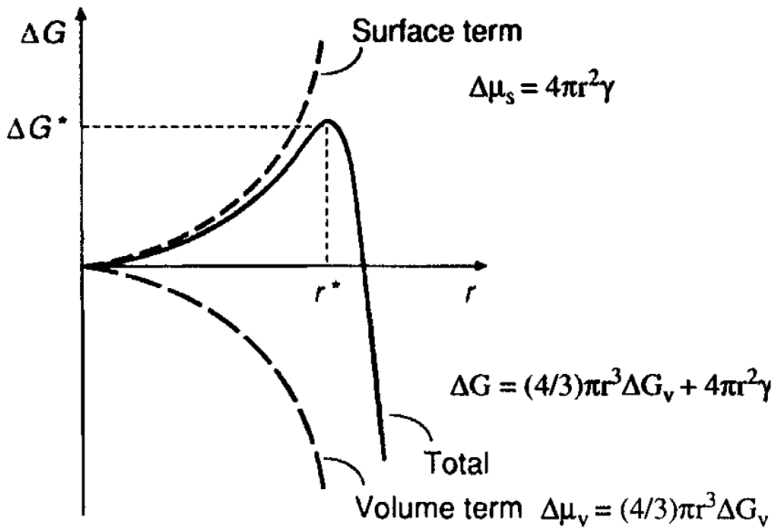
SECTION-A: Total 20 marks
Each question carries 4 marks

S. No.		**CO**
Q 1	What are the unique properties of Kevlar and what are it's applications? (4)	CO2
Q 2	What do you understand by the term 'dangling bonds' and how is it related to the origin of surface energy? (4)	CO1
Q 3	Mention any two mechanisms through which nanomaterials can reduce their surface energy. (4)	CO2
Q 4	Draw a schematic potential energy curve to show the interaction between two atoms separated by any distance (r). (4)	CO1
Q 5	Briefly discuss the sol-gel method for synthesis of nanoparticles. (4)	CO3

SECTION-B : Total 40 marks
Each question carries 10 marks

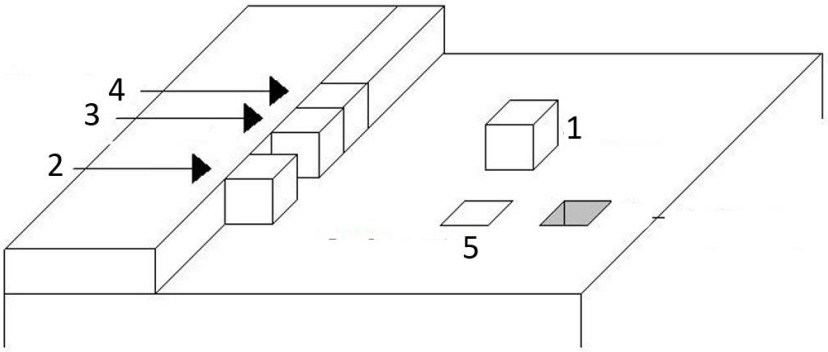
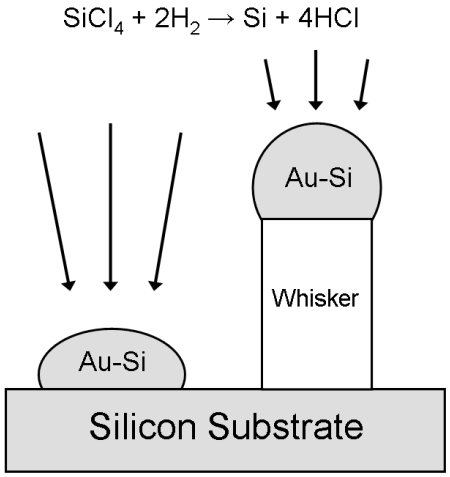
Q 6 — CO3

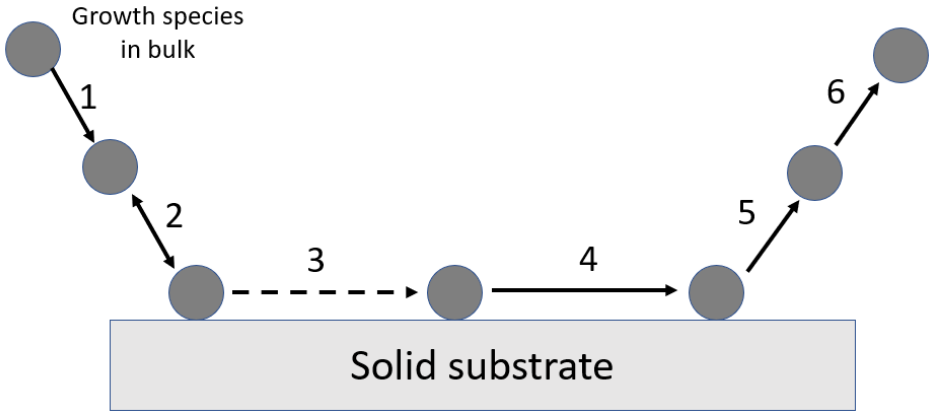
Consider the homogenous nucleation of nanoparticles in a solution. Fig. below shows the variation of free energy as a function of size of nanoparticle (r).



Answer the following:

a) From the graph, identify the smallest sized stable nanoparticle that can be created through homogenous nucleation. (2)
b) Derive an expression for this critical size as a function of ΔG_v and γ. (4)
c) Briefly discuss four ways in which this critical size can be reduced to enable formation of smaller nanoparticles. (4)

Q 7	Using a schematic, briefly discuss the differences between the three types of growth: Island growth, Layer growth and Island-layer growth. (10)	CO3
Q 8	Using a schematic, briefly discuss the sputtering process used for depositing thin films on a substrate. (10)	CO4
Q 9	The figure below shows various atomic positions (1 to 5) in Terrace-Ledge-Kink (TLK) model that is used to describe thermodynamics of crystal surface formation.  Answer the following: a) Identify and name each of the five atomic positions. (5) b) Write the coordination number (i.e., the number of nearest neighbours) for each site. (5)	CO4
SECTION-C: Total 40 marks		
Q 10	The figure below shows the formation of silicon nanorods (Si-whisker) through Vapour-Liquid-Solid (VLS) growth process.  Answer the following: a) VLS process requires use of a second-phase material (catalyst or impurity). Identify the second-phase material that has been used in above figure. (2) b) Briefly describe the growth process of Si nanorods as shown in above figure (8). c) In VLS process, discuss the role of wetting angle in controlling the diameter of nanowires (5). d) In VLS process, the equilibrium vapour pressure of the catalyst over liquid crystal must be very small. Why? (5)	CO3

Q 11	The figure below shows the six steps for crystal growth in evaporation-condensation growth process.  Answer the following: a) Briefly describe each of the six steps. (12) b) The residence time (τ) and mean diffusion distance (X) of a growth species on substrate depends on Temperature and vibrational frequency (ν). Briefly discuss the change in τ and X if: (i) Temperature is increased, and (ii) ν is increased. (6) c) Which of these six steps do you think is often the rate-controlling step? (2)	CO4