2025/05

SET A

M.Sc. CHEMISTRY
FOURTH SEMESTER
MATERIAL CHEMISTRY & THERMODYNAMICS
MSC – 401 [REPEAT]

[USE OMR FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

(Objective)

Time: 30 min. **Marks: 20**

Choose the correct answer from the following: ***1×20=20***

1. What is the primary effect exhibited by a piezoelectric material when subjected to mechanical stress?
   a. Change in magnetization
   b. Change in refractive index
   c. Generation of electric charge
   d. Change in shape

2. Which effect describes the change in shape or volume of a material in response to light?
   a. Photoelastic effect
   b. Photostriction effect
   c. Piezoelectric effect
   d. Thermo-Mechanical effect

3. What is a key consideration in designing smart materials using supramolecular engineering?
   a. Only material composition
   b. Only supramolecular structure
   c. Property requirements and stimulus type
   d. Only scalability and manufacturability

4. Which of the following smart materials changes its electrical conductivity in response to light?
   a. Smart gel
   b. Photo-conducting material
   c. Magneto-rheological material
   d. Electro-rheological material

5. Which smart material is commonly used in fire alarm systems due to its ability to change shape at specific temperatures?
   a. Piezoelectric material
   b. Electro-active polymer
   c. Conductive polymer
   d. Shape-memory alloy

6. What does the 2nd law of thermodynamics state about systems in non-equilibrium?
   a. Entropy always decreases
   b. Entropy remains constant
   c. Entropy tends to increase
   d. Irreversible Process

7. In non-equilibrium thermodynamics, what does a negative entropy production indicate?
   a. Equilibrium state
   b. Energy conservation
   c. Reversible process
   d. Irreversible Process

8. What is the primary focus of non-equilibrium thermodynamics?
   a. Systems in thermal equilibrium
   b. Systems at constant pressure
   c. Systems out of thermal equilibrium
   d. Systems at absolute zero

9. In non-equilibrium thermodynamics, Onsager reciprocal relations apply to
   a. Reversible processes only
   b. Coupled irreversible processes
   c. Isolated systems only
   d. Adiabatic processes

10. The concept of "local equilibrium" in non-equilibrium thermodynamics implies
   a. Spatial variation in thermodynamic properties
   b. Constant temperature throughout the system
   c. Uniform distribution of energy
   d. Absence of entropy production

11. The correct thermodynamic relation among the following is
   a. $\left(\frac{\partial U}{\partial V}\right)_S = -P$
   b. $\left(\frac{\partial H}{\partial V}\right)_S = -P$
   c. $\left(\frac{\partial G}{\partial V}\right)_S = -P$
   d. $\left(\frac{\partial A}{\partial V}\right)_S = -S.$

12. The Maxwell's relationship derived from the equation $dG = VdP - SdT$ is
   a. $\left(\frac{\partial V}{\partial T}\right)_P = \left(\frac{\partial S}{\partial P}\right)_T$
   b. $\left(\frac{\partial P}{\partial V}\right)_T = \left(\frac{\partial T}{\partial S}\right)_P$
   c. $\left(\frac{\partial V}{\partial T}\right)_P = -\left(\frac{\partial S}{\partial P}\right)_T$
   d. $\left(\frac{\partial P}{\partial V}\right)_T = -\left(\frac{\partial T}{\partial S}\right)_P$

13. A process is carried out t constant volume and at a constant entropy. It will be spontaneous if
   a. $\Delta G < 0$
   b. $\Delta U < 0$
   c. $\Delta H < 0$
   d. $\Delta A < 0$

14. The chemical potential μ of a pure substance is equal to
   a. Molar Gibbs energy
   b. Entropy
   c. Internal Energy
   d. None of the above

15. The correct relation for Clausius–Clapeyron equation is
   a. $\frac{d \ln p}{dT} = \frac{\Delta_{vap} H}{RT^2}$
   b. $\frac{dp}{dT} = \frac{\Delta_{vap} H}{(RT/p)}$
   c. $\frac{d \ln p}{RdT} = \frac{\Delta_{vap} H}{RT^2}$
   d. None of the above

16. In dip-pen nanolithography the tip of an AFM is
   a. Diamond cutter
   b. Cantilever
   c. Ink pen
   d. Smart pen

17. Which one of the following is *not* a drawback of CVD process?
   a. Use of toxic chemicals
   b. Turbulent flow
   c. Use of high pressure
   d. Use of coolant

18. Chemical beam epitaxy (CBE) is a combination of
   a. MOCVD and MBE
   b. MOCVD and ALD
   c. CVD and MBE
   d. ALD and MBE

19. In Grätzel cell the medium used to transfer electrons from an organoruthenium dye to a conductor is
    a. AgO
    b. ZnO
    c. TiO_2
    d. SnO

20. Plasma method of synthesis falls under
    a. Chemical synthesis
    b. Vapour synthesis
    c. Hydrothermal synthesis
    d. Metal oxide synthesis

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Descriptive

Time : 2 hrs. 30 mins. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. a. What is the primary difference between active and passive smart materials in terms of energy requirement? Distinguish between shape memory alloys and electroactive polymers in terms of their stimuli response and applications. **3+3+2+2 =10**
   b. Explain the Curiee-Prigogine principle in non-equilibrium thermodynamics.
   c. Establish the relation, dH = TdS + VdP
   d. Write two differences between vapour phase and solution-based techniques for nanomaterial synthesis.

2. a. Explain the principle of thermo-mechanical effect and its applications in thermostats. **1.5+1.5+3 +2+2=10**
   b. What is the Joule Magnetization Effect? Describe its significance in temperature-sensitive applications.
   c. Classify and define smart materials into any four different categories based on functionality and provide one example for each.
   d. Why are magneto-rheological and electro-rheological materials considered as smart materials? Explain it with example.
   e. Explain how piezoelectric materials are used in airbag sensors in vehicles.

3. a. How do thermodynamic forces drive irreversible processes? **3+2+3+2 =10**
   b. State the Onsager reciprocal relations.
   c. Compare and contrast equilibrium thermodynamics with non-equilibrium thermodynamics, highlighting their key differences.
   d. Discuss one application of non-equilibrium thermodynamics.

4. a. What is the driving force for heat flow in a non-equilibrium system? Explain briefly. 2+5+3 =10
   b. Explain the concept of entropy production. Write the criteria's for non-equilibrium states.
   c. Explain the process of preparation of carbon nanotubes (CNT).

5. a. Write the basic steps involved in solution-based technique. 2+2+3+3 =10
   b. What is Ostwald ripening and how can it be prevented?
   c. Give two examples of ancient findings where nanotechnology was used. Mention the type of nanomaterial used.
   d. Write the conditions and challenges experienced by use of nanomaterials.

6. a. Mention two uses of smart materials in communication networks and briefly explain their role. 2+1+1+1 +2+3=10
   b. Which smart material is used in self-cleaning glasses that respond to light?
   c. Name the smart material used in fitness trackers to detect footsteps.
   d. What type of smart material is used in smart windows to change opacity with electric signals?
   e. Write a short note on "Terfenol-D".
   f. Explain the working principle of "AFM" scanning technique.

7. a. Establish the relation $(\partial T/\partial V)_S = -(\partial P/\partial S)_V$ 2+2+3+3 =10
   b. Derive the Gibbs Duhem Equation? Write the applications of this equation?
   c. What is Chemical potential? Derive the relation $dG = \mu_A dn_A + \mu_B dn_B$
   d. Derive the relation for Gibbs energy of mixing for perfect gases

$$\Delta_{mix} G = nRT\,(X_A \ln X_A + X_B \ln X_B)$$

8. a. Derive the following Clausius-Clapeyron relation 3+3+2+2 =10

$$\int_{\ln p^*}^{\ln p} d\ln p = -\frac{\Delta_{vap}H}{R}\left(\frac{1}{T} - \frac{1}{T^*}\right)$$

   b. What is fugacity and fugacity coefficient? How is it related to real gases? Explain.
   c. Discuss the physical interpretation of the dependence of the Gibbs energy on the temperature and pressure.
   d. Write the difference between homoepitaxy and heteroepitaxy.

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