Time: 90 min   **Max. Marks: 50**

Section A   (10 × 1 = 10 marks)

*Answer **all** questions. Choose the most appropriate option.*

1. The mineral **dolomite** is best represented by
    a) $CaCO_3$ b) $CaSO_4 \cdot 2H_2O$ c) $CaMg(CO_3)_2$ d) $MgCO_3$

2. In the Ellingham diagram, the slope of the line for $CO \rightarrow CO_2$ is negative because the reaction is
    a) exothermic with $\Delta S > 0$ b) exothermic with $\Delta S < 0$ c) endothermic with $\Delta S > 0$ d) endothermic with $\Delta S < 0$

3. **Cryolite** is added to the Hall–Héroult cell primarily to
    a) lower the density of molten Al   b) increase electrical conductivity
    c) lower the melting point of alumina   d) remove silica gangue

4. During electrolytic refining of copper, the anode mud is rich in
    a) Zn and Fe   b) Ag and Au   c) Pt and Pd   d) Sn and Pb

5. Boron forms the volatile compound **BCl₃** because
    a) its B–Cl bonds are purely ionic   b) B has an empty d-orbital
    c) B is electron-deficient   d) chlorine is less electronegative than boron

6. The compound with the formula **$(SiO_2)n$** in which every O atom is shared between two tetrahedra is
    a) an orthosilicate   b) a sheet silicate   c) a three-dimensional or tecto-silicate
    d) a cyclic silicate

7. A linear chain silicone may be represented by
    a) $-SiO_2-$ b) $-Si(R)_2-O-Si(R)_2-O-$ c) $-Si-O-Si-O-Si-$ (all SiR_3)   d) $(-SiO_3-)n$

8. **Graphene** differs from graphite because graphene
    a) is electrically insulating   b) is one atom thick   c) contains sp^3 carbon   d) has only pentagons

9. The allotrope **C_{60}** is nick-named "buckyball" because it resembles
    a) a rugby ball   b) a soccer ball   c) a tennis ball   d) a cricket ball

10. The mixture of equal volumes of CO and N_2 obtained by passing air over red-hot coke is called
    a) water gas   b) synthesis gas   c) producer gas   d) Mond gas

Section B   (7 × 2 = 14 marks)

*Answer **any five** questions. Each question carries 2 marks.*

11. Distinguish **roasting** from **calcination** with one balanced equation for each.
12. State two reasons why **CO** is a better reducing agent than carbon below 983 K.
13. Write two industrial uses of **borax glass ($NaBO_2$)**.
14. Explain why **AlCl₃** fumes in moist air.
15. What structural feature makes **silicones** excellent high-temperature lubricants?

16. Predict whether Mg can reduce Al_2O_3 at 1200 K. Briefly justify using thermodynamic reasoning (no diagram required).

17. A sample of **galena (PbS)** is contaminated with ZnS. Name the reagent that selectively depresses ZnS during froth-flotation and write the suppressing reaction.

Section C (7 × 3 = 21 marks)

*Answer **any five** questions. Each question carries 3 marks.*

18. (a) Write the electrode reactions in the **Downs cell** for Na extraction.
    (b) Give one reason each for adding (i) $CaCl_2$ and (ii) graphite anode.

19. Describe the **zone-refining** principle and explain why it is particularly suitable for producing ultrapure Ge.

20. Draw a neat labelled sketch of the **Hall–Héroult cell**, indicating anode, cathode, electrolyte composition and temperature range.

21. Illustrate the formation of two **three-centre two-electron (3c–2e)** bonds in diborane with a simple orbital diagram.

22. Outline the steps involved in converting **colemanite** to borax, giving balanced equations.

23. Explain the **Fischer–Tropsch synthesis** of hydrocarbons from CO and H_2, writing two general equations.

24. Give three ways in which the structures of **diamond, graphite and graphene** differ, correlating each difference with a physical property.

Section D (3 × 5 = 15 marks)

*Answer **one question from each internal choice**.*

25. a) Describe the complete extraction of **copper** from copper pyrites, including concentration, roasting, smelting, Bessemerisation and electrolytic refining.

   OR

25. b) Using the Ellingham diagram concept, discuss the conditions under which **FeO** can be reduced by (i) C and (ii) CO. Support your discussion with suitable free-energy equations.

26. a) Explain the chemistry of **boric acid**: preparation from colemanite, structure (with hydrogen bonding), acidic behaviour in water and one major use.

   OR

26. b) Classify silicates into **ortho-, pyro-, cyclic, chain (single & double), sheet and tecto-silicates** with one example and structural sketch for each class.

27. a) With equations, show how **alumina** is concentrated from bauxite by the **Baeyer's process** and subsequently leached and calcined in the **Hall process** before electrolysis.

   OR

27. b) "**Carbon monoxide is both a poison and a valuable industrial raw material.**" Discuss this statement under the headings (i) physiological effect, (ii) metal carbonyl formation, and (iii) water-gas shift equilibrium.