

**MT : METALLURGICAL ENGINEERING**

Duration : Three Hours

Maximum Marks :150

**Read the following instructions carefully**

1. This question paper contains **16** printed pages including pages for rough work. Please check all pages and report discrepancy, if any.
2. Write your registration number, your name and name of the examination centre at the specified locations on the right half of the ORS.
3. Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your paper code.
4. All the questions in this question paper are of objective type.
5. Questions must be answered on **Objective Response Sheet (ORS)** by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number on the left hand side of the ORS. **Each question has only one correct answer.** In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question will be treated as a wrong answer.
6. Questions 1 through 20 are 1-mark questions and questions 21 through 85 are 2-mark questions.
7. Questions 71 through 73 is one set of common data questions, questions 74 and 75 is another pair of common data questions. The question pairs (76, 77), (78, 79), (80, 81), (82, 83) and (84, 85) are questions with linked answers. The answer to the second question of the above pairs will depend on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the second question in the pair will not be evaluated.
8. Un-attempted questions will carry zero marks.
9. **NEGATIVE MARKING:** For Q.1 to Q.20, **0.25** mark will be deducted for each wrong answer. For Q.21 to Q.75, **0.5** mark will be deducted for each wrong answer. For the pairs of questions with linked answers, there will be negative marks only for wrong answer to the first question, i.e. for Q.76, Q.78, Q.80, Q.82 and Q.84, **0.5** mark will be deducted for each wrong answer. There is no negative marking for Q.77, Q.79, Q.81, Q.83 and Q.85.
10. Calculator **without data connectivity** is allowed in the examination hall.
11. Charts, graph sheets and tables are **NOT** allowed in the examination hall.
12. Rough work can be done on the question paper itself. Additional blank pages are given at the end of the question paper for rough work.

**Useful Data**

Universal gas constant =  $8.314 \text{ J mol}^{-1} \text{ K}^{-1}$

Avogadro's Number =  $6.023 \times 10^{23} \text{ atoms mol}^{-1}$

Note: All compositions are in wt.% unless otherwise specified.

**Q. 1 – Q. 20 carry one mark each.**

- Q.1 The yield point phenomenon observed in annealed low carbon steels is due to the presence of  
(A) silicon (B) chromium (C) phosphorous (D) carbon
- Q.2 In a tensile test of a ductile material, necking starts at  
(A) lower yield stress (B) upper yield stress  
(C) ultimate tensile strength (D) just before fracture
- Q.3 Fatigue resistance of a steel is reduced by  
(A) decarburization (B) polishing the surface  
(C) reducing the grain size (D) shot peening
- Q.4 The stress concentration factor  $K_t$  for a circular hole located at the center of a plate is  
(A) 0 (B) 1 (C) 3 (D) tends to  $\infty$
- Q.5 Cassiterite is an important source for  
(A) tin (B) titanium (C) molybdenum (D) thorium
- Q.6 High top pressure in the blast furnace  
(A) decreases the time of contact between gas and solid  
(B) increases the time of contact between gas and solid  
(C) increases fuel consumption  
(D) increases the rate of solution loss reaction
- Q.7 For a closed system of fixed internal energy and volume, at equilibrium  
(A) Gibb's free energy is minimum (B) entropy is maximum  
(C) Helmholtz's free energy is minimum (D) enthalpy is maximum
- Q.8 Intergranular corrosion of 18-8 stainless steel can NOT be prevented by  
(A) reducing the carbon content to less than 0.05%  
(B) quenching it from high temperature to prevent chromium carbide precipitation  
(C) adding strong carbide forming elements  
(D) increasing the carbon content
- Q.9 Riser is NOT required for the castings of  
(A) grey cast iron (B) white cast iron (C) Al-4% Cu (D) Al-12% Si
- Q.10 The NDT technique used to detect deep lying defects in a large sized casting is  
(A) liquid penetrant inspection (B) magnetic particle inspection  
(C) ultrasonic inspection (D) eddy current inspection

- Q.11 The maximum number of phases in a quaternary system at atmospheric pressure are  
 (A) 2 (B) 3 (C) 4 (D) 5
- Q.12 In Cu-Al phase diagram, the solubility of Al in Cu at room temperature is about 10% and that of Cu in Al is less than 1%. The Hume-Rothery rule that justifies this difference is  
 (A) size factor (B) electro-negativity  
 (C) structure (D) valency
- Q.13 Mannesmann process  
 (A) is a cold working process  
 (B) is used for making thin walled seamless tubes  
 (C) uses parallel rolls  
 (D) is used for making thick walled seamless tubes
- Q.14 The intensive thermodynamic variables among the following are  
 (P) pressure (Q) volume (R) temperature (S) enthalpy  
 (A) P, Q (B) P, R (C) R, S (D) Q, R
- Q.15 In a binary phase diagram, the activity of the solute in a two phase field at a given temperature  
 (A) increases linearly with the solute content  
 (B) decreases linearly with the solute content  
 (C) remains constant  
 (D) is proportional to the square root of the solute content
- Q.16 In Jominy curves of steel A (Fe-0.4% C) and steel B (Fe-0.4% C -1.0% Ni),  
 (A) depth of hardening in steel A is more than in steel B  
 (B) depth of hardening in steel B is more than in steel A  
 (C) hardness at the quenched end in steel A is more than in steel B  
 (D) hardness at the quenched end in steel B is more than in steel A
- Q.17 Determinant of  $\begin{pmatrix} 3 & 1 & 2 \\ 1 & 2 & 1 \\ 4 & 2 & 3 \end{pmatrix}$  is  
 (A) -2 (B) -1 (C) 1 (D) 2
- Q.18  $\int \frac{dx}{a+bx}$  is  
 (A)  $\frac{1}{b} \ln(a+bx) + c$  (B)  $\ln(a+bx) + c$  (C)  $b \ln(a+bx) + c$  (D)  $\frac{1}{a} \ln(a+bx) + c$
- Q.19 The value of  $dy/dx$  for the following data set at  $x = 3.5$ , computed by central difference method, is

x	1	2	3	4	5
y	0	3	8	15	24

- (A) 3.5 (B) 7 (C) 10.5 (D) 14

- Q.20 The velocity at which particles from a fluidized bed are carried away by the fluid passing through it, is known as
- (A) elutriation velocity (B) terminal velocity  
(C) minimum fluidization velocity (D) superficial velocity

**Q. 21 to Q.75 carry two marks each.**

- Q.21 A metal with an average grain size of  $36 \mu\text{m}$  has yield strength of 250 MPa and that with  $4 \mu\text{m}$  has 500 MPa. The friction stress of the metal in MPa is
- (A) 31.2 (B) 62.5 (C) 125 (D) 250
- Q.22 The stacking sequence of close packed planes with a stacking fault is
- (A)  $abcabcabc$  (B)  $ababababab$   
(C)  $abcacabcab$  (D)  $abcabacba$
- Q.23 The slip directions on a  $(\bar{1}\bar{1}\bar{1})$  plane of a fcc crystal are
- (A)  $[\bar{1}01]$ ,  $[011]$ ,  $[110]$  (B)  $[101]$ ,  $[\bar{1}\bar{1}0]$ ,  $[10\bar{1}]$   
(C)  $[\bar{1}0\bar{1}]$ ,  $[\bar{1}\bar{1}0]$ ,  $[0\bar{1}\bar{1}]$  (D)  $[0\bar{1}\bar{1}]$ ,  $[0\bar{1}\bar{1}]$ ,  $[\bar{1}\bar{1}0]$
- Q.24 The correct statements among the following are
- (P) screw dislocations cannot climb  
(Q) screw dislocations cannot cross-slip  
(R) edge dislocations cannot climb  
(S) edge dislocations cannot cross-slip
- (A) P, R (B) P, S (C) Q, R (D) Q, S
- Q.25 A steel bar (elastic modulus = 200 GPa and yield strength = 400 MPa) is loaded to a tensile stress of 1 GPa and undergoes a plastic strain of 2%. The elastic strain in the bar in percent is
- (A) 0 (B) 0.2 (C) 0.5 (D) 2.0
- Q.26 The ASTM grain size number of a material which shows 64 grains per square inch at a magnification of 200X is
- (A) 5 (B) 6 (C) 7 (D) 8
- Q.27 Two samples P and Q of a brittle material have crack lengths in the ratio 4:1. The ratio of fracture strengths of P and Q, measured normal to the cracks, will be
- (A) 1:4 (B) 1:2 (C) 2:1 (D) 4:1
- Q.28 The structure-sensitive properties are
- (P) elastic modulus  
(Q) yield strength  
(R) melting point  
(S) fracture strength
- (A) P, S (B) Q, S (C) Q, R (D) P, R

- Q.29 The time taken for 50% recrystallization of cold worked Al is 100 hours at 500 K and 10 minutes at 600 K. Assuming Arrhenius kinetics, the activation energy for recrystallization in  $\text{kJ mol}^{-1}$  is  
 (A) 50 (B) 80 (C) 160 (D) 320
- Q.30 Match the mechanical behaviour in Group 1 with the terms in Group 2
- |                        |                                 |
|------------------------|---------------------------------|
| <u>Group 1</u>         | <u>Group 2</u>                  |
| (P) Low cycle fatigue  | (1) Charpy test                 |
| (Q) Creep              | (2) Portevin-LeChatelier effect |
| (R) Impact toughness   | (3) Coffin-Manson equation      |
| (S) Stretcher strain   | (4) Larson-Miller parameter     |
|                        | (5) Jominy test                 |
| (A) P-2, Q-4, R-1, S-5 | (B) P-2, Q-1, R-5, S-3          |
| (C) P-3, Q-4, R-1, S-2 | (D) P-3, Q-1, R-4, S-5          |
- Q.31 Match the processes in Group 1 with the physical principles in Group 2
- |                            |                                       |
|----------------------------|---------------------------------------|
| <u>Group 1</u>             | <u>Group 2</u>                        |
| (P) Flotation              | (1) Differential initial acceleration |
| (Q) Jigging                | (2) Differential lateral movement     |
| (R) Tabling                | (3) Difference in density             |
| (S) Heavy media separation | (4) Modification of surface tension   |
| (A) P-4, Q-1, R-2, S-3     | (B) P-4, Q-1, R-3, S-2                |
| (C) P-2, Q-3, R-4, S-1     | (D) P-1, Q-3, R-4, S-2                |
- Q.32 Which of the following is a solution for  $\frac{\partial z}{\partial t} = \frac{\partial^2 z}{\partial x^2}$
- |   |  |
|---|--|
| (A) $z(x, t) = [A \sin x] e^{-\lambda^2 t}$ | (B) $z(x, t) = [A \sin(\lambda x)] e^{-\lambda^2 t}$ |
| (C) $z(x, t) = \frac{A}{t} e^{-x^2/t}$      | (D) $z(x, t) = [B \cos(\lambda x)] \sqrt{t}$         |
- Q.33 Match the unit processes in Group 1 with the objectives in Group 2
- |                        |  |
|------------------------|--|
| <u>Group 1</u>         | <u>Group 2</u>                                 |
| (P) Leaching           | (1) Precipitation of metal in aqueous solution |
| (Q) Cementation        | (2) Selective dissolution of metal             |
| (R) Roasting           | (3) Conversion of matte to metal               |
| (S) Converting         | (4) Conversion of sulphide to oxide            |
|                        | (5) Separation of metal from slag              |
| (A) P-2, Q-1, R-3, S-5 | (B) P-2, Q-1, R-4, S-3                         |
| (C) P-3, Q-4, R-5, S-2 | (D) P-4, Q-3, R-2, S-1                         |
- Q.34 Match the following metals in Group 1 with their production methods in Group 2
- |                        |                        |
|------------------------|------------------------|
| <u>Group 1</u>         | <u>Group 2</u>         |
| (P) Titanium           | (1) Mond's process     |
| (Q) Nickel             | (2) Pidgeon's process  |
| (R) Magnesium          | (3) Imperial smelting  |
| (S) Zinc               | (4) Kroll's process    |
|                        | (5) Cyanidation        |
| (A) P-5, Q-2, R-3, S-4 | (B) P-3, Q-5, R-4, S-2 |
| (C) P-4, Q-1, R-2, S-3 | (D) P-4, Q-1, R-5, S-3 |

- Q.35 Manganese recovery in steelmaking is aided by  
 (P) oxidizing slag  
 (Q) reducing slag  
 (R) high temperature  
 (S) low temperature  
 (T) acidic slag  
 (A) P, Q (B) Q, S (C) R, T (D) Q, R
- Q.36 A flotation plant treats 100 tons of chalcopyrite containing 2% Cu and produces 6 tons of concentrate. The concentrate has 25% Cu. The percentage Cu in the tailings is  
 (A) 0.35 (B) 0.53 (C) 0.86 (D) 0.93
- Q.37 One ton of liquid steel initially containing 0.08% S is brought into equilibrium with 0.1 ton of liquid slag containing no sulphur. The sulphur distribution ratio  $(\%S)_{\text{slag}}/[\%S]_{\text{metal}}$  is 30 at equilibrium. The final sulphur content of steel in wt.% is  
 (A) 0.01 (B) 0.02 (C) 0.03 (D) 0.04
- Q.38 Deoxidation of liquid steel with ferrosilicon produces spherical silica particles. The particles of 5  $\mu\text{m}$  diameter take 3000 minutes to float up through a 2 m height of liquid steel. For particles of 50  $\mu\text{m}$  diameter to float up through the same height, the time required in minutes is  
 (A) 30 (B) 300 (C) 960 (D) 3000
- Q.39 Match applications in Group 1 with the commonly used corrosion protection methods in Group 2
- | Group 1                     | Group 2               |
|-----------------------------|-----------------------|
| (P) Seagoing vessel         | (1) Inorganic coating |
| (Q) Underground pipeline    | (2) Sacrificial anode |
| (R) Electric traction tower | (3) Aluminium paint   |
| (S) Electric poles          | (4) Impressed current |
|                             | (5) Galvanizing       |
- (A) P-2, Q-4, R-5, S-3 (B) P-2, Q-3, R-5, S-1  
 (C) P-1, Q-2, R-5, S-4 (D) P-4, Q-3, R-1, S-2
- Q.40 For a regular solution A-B,  $\overline{\Delta H_B}$  is 2660.5 J at  $x_B = 0.6$ . The critical point of the miscibility gap in the system would be at  
 (A)  $x_B = 0.5$ ,  $T = 1000$  K (B)  $x_B = 0.6$ ,  $T = 1000$  K  
 (C)  $x_B = 0.5$ ,  $T = 500$  K (D)  $x_B = 0.6$ ,  $T = 2000$  K
- Q.41 For  $\text{Ni} + 0.5\text{O}_2 = \text{NiO}$ ,  $\Delta G^0 = -250,000 + 100T$  Joules. At 1000 K, the  $p_{\text{O}_2}$  in equilibrium with Ni/NiO in atm is  
 (A)  $2.13 \times 10^{-16}$  (B)  $8.54 \times 10^{-16}$  (C)  $1.46 \times 10^{-8}$  (D)  $2.92 \times 10^{-8}$
- Q.42 The planar density for (111) plane in a fcc crystal is  
 (A) 0.68 (B) 0.74 (C) 0.85 (D) 0.91
- Q.43 Iridium has fcc structure. Its density and atomic weight are  $22,400 \text{ kg m}^{-3}$  and 192.2, respectively. The atomic radius of iridium in nm is  
 (A) 0.126 (B) 0.136 (C) 0.146 (D) 0.156

Q.44 Match the names in Group 1 with the invariant reactions in binary phase diagrams in Group 2

Group 1

- (P) Eutectic  
(Q) Eutectoid  
(R) Peritectoid  
(S) Monotectic

Group 2

- (1)  $S1 = S2 + S3$   
(2)  $L = S1 + S2$   
(3)  $L1 = L2 + S$   
(4)  $S1 + S2 = S3$

- (A) P-2, Q-1, R-3, S-4  
(C) P-3, Q-4, R-2, S-1

- (B) P-2, Q-1, R-4, S-3  
(D) P-4, Q-3, R-1, S-2

Q.45 Match the properties in Group 1 with the units in Group 2

Group 1

- (P) Thermal conductivity  
(Q) Heat transfer coefficient  
(R) Specific heat  
(S) Diffusivity

Group 2

- (1)  $J m^{-2} s^{-1} K^{-1}$   
(2)  $J m^{-1} s^{-1} K^{-1}$   
(3)  $m^2 s^{-1}$   
(4)  $J mol^{-1} K^{-1}$

- (A) P-1, Q-2, R-4, S-3  
(C) P-2, Q-1, R-4, S-3

- (B) P-2, Q-3, R-1, S-4  
(D) P-2, Q-4, R-3, S-1

Q.46 Match the heat treatment processes of steels in Group 1 with the microstructural features in Group 2

Group 1

- (P) Quenching  
(Q) Maraging  
(R) Tempering  
(S) Austempering

Group 2

- (1) Bainite  
(2) Martensite  
(3) Intermetallic precipitates  
(4) Epsilon carbide

- (A) P-2, Q-3, R-1, S-4  
(C) P-2, Q-3, R-4, S-1

- (B) P-1, Q-3, R-2, S-4  
(D) P-3, Q-2, R-1, S-4

Q.47 Match the nonferrous alloys in Group 1 with their applications in Group 2

Group 1

- (P) Ti alloy  
(Q) Zr alloy  
(R) Ni alloy  
(S) Cu alloy

Group 2

- (1) Nuclear reactors  
(2) Bells  
(3) Dental implants  
(4) Gas Turbines

- (A) P-3, Q-1, R-4, S-2  
(C) P-2, Q-1, R-3, S-4

- (B) P-2, Q-3, R-4, S-1  
(D) P-3, Q-4, R-1, S-2

Q.48 Match the materials in Group 1 with their functional applications in Group 2

Group 1

- (P)  $Nb_3Sn$   
(Q) GaAs  
(R) Fe-4%Si alloy  
(S)  $SiO_2$

Group 2

- (1) Dielectric  
(2) Soft magnet  
(3) Superconductor  
(4) Semiconductor

- (A) P-3, Q-1, R-4, S-2  
(C) P-3, Q-2, R-4, S-1

- (B) P-1, Q-4, R-2, S-3  
(D) P-3, Q-4, R-2, S-1

- Q.49 An annealed hypoeutectoid steel has 10% of proeutectoid ferrite at room temperature. The eutectoid carbon content of the steel is 0.8%. The carbon content in the steel in percent is  
 (A) 0.58 (B) 0.68 (C) 0.72 (D) 0.78
- Q.50 The melting point and latent heat of fusion of copper are 1356 K and 13 kJ mol<sup>-1</sup>, respectively. Assume that the specific heats of solid and liquid are same. The free energy change for the liquid to solid transformation at 1250 K in kJ mol<sup>-1</sup> is  
 (A) -4 (B) -3 (C) -2 (D) -1
- Q.51 According to the Clausius-Clapeyron equation, the melting point of aluminium  
 (A) increases linearly with pressure  
 (B) decreases linearly with pressure  
 (C) increases exponentially with pressure  
 (D) does not vary with pressure
- Q.52 Match the cast irons in Group 1 with the distinguishing microstructural features in Group 2
- | <u>Group 1</u>          | <u>Group 2</u>         |
|-------------------------|------------------------|
| (P) Grey cast iron      | (1) Temper graphite    |
| (Q) Ductile cast iron   | (2) Pearlite           |
| (R) Malleable cast iron | (3) Graphite flakes    |
| (S) White cast iron     | (4) Massive cementite  |
|                         | (5) Nodular graphite   |
| (A) P-3, Q-5, R-4, S-2  | (B) P-1, Q-5, R-4, S-2 |
| (C) P-2, Q-4, R-5, S-3  | (D) P-3, Q-5, R-1, S-4 |
- Q.53 Match the casting defects in Group 1 with causes given in Group 2
- | <u>Group 1</u>         | <u>Group 2</u>                   |
|------------------------|----------------------------------|
| (P) Hot tear           | (1) Insufficient melt super heat |
| (Q) Misrun             | (2) High residual stresses       |
| (R) Blister            | (3) Improper venting.            |
| (S) Rat tail           | (4) Expansion of sand            |
| (A) P-1, Q-2, R-3, S-4 | (B) P-3, Q-4, R-1, S-2           |
| (C) P-4, Q-3, R-2, S-1 | (D) P-2, Q-1, R-3, S-4           |
- Q.54 The thickness of a plate is to be reduced from 60 to 30 mm by multipass rolling. The roll radius is 350 mm and coefficient of friction is 0.15. Assuming equal draft in each pass, the minimum number of passes required would be  
 (A) 2 (B) 4 (C) 5 (D) 6
- Q.55 Match the particle morphologies in Group 1 with the powder production methods in Group 2
- | <u>Group 1</u>                                 | <u>Group 2</u>                 |
|--|--------------------------------|
| (P) Superalloy powder with rounded morphology  | (1) Carbonyl process           |
| (Q) Monosized spherical Ta powder              | (2) Gas atomization            |
| (R) Fe powder with <i>onion peel</i> structure | (3) Oxide reduction            |
| (S) Irregularly shaped W powder                | (4) Rotating electrode process |
| (A) P-2, Q-1, R-4, S-3                         | (B) P-1, Q-4, R-3, S-2         |
| (C) P-2, Q-4, R-1, S-3                         | (D) P-4, Q-1, R-2, S-3         |



- Q.56 One mole of monoatomic ideal gas is reversibly and isothermally expanded at 1000 K to twice its original volume. The work done by the gas in Joules is  
 (A) 2430 (B) 2503 (C) 5006 (D) 5763

- Q.57 In the Ellingham diagram  $C \rightarrow CO$  line intersects  $M \rightarrow MO$  line at temperature  $T_1$  and  $N \rightarrow NO$  line at temperature  $T_2$ . M and N are metals.  $T_2$  is greater than  $T_1$ . The correct statements among the following are

- (P) carbon will reduce both MO and NO at temperatures  $T > T_2$   
 (Q) carbon will reduce both MO and NO at temperatures between  $T_1$  and  $T_2$   
 (R) carbon will reduce both MO and NO at temperatures  $T < T_1$   
 (S) carbon will reduce MO but not NO at temperatures between  $T_1$  and  $T_2$   
 (T) carbon will reduce NO but not MO at temperatures between  $T_1$  and  $T_2$

- (A) P, S (B) Q, T (C) R, S (D) P, T

- Q.58 Match the forms of corrosion in Group 1 with the typical examples in Group 2

Group 1

- (P) Pitting corrosion  
 (Q) Crevice corrosion  
 (R) Galvanic corrosion  
 (S) Stress corrosion cracking

- (A) P-3, Q-2, R-4, S-1  
 (C) P-3, Q-4, R-2, S-1

Group 2

- (1) Austenitic stainless steel in chloride environment  
 (2) Nut bolt with gasket  
 (3) Painted food cans  
 (4) Steel studs in copper plate

- (B) P-1, Q-3, R-4, S-2  
 (D) P-2, Q-3, R-4, S-1

- Q.59 Given the following assertion 'a' and the reason 'r', the correct option is

Assertion a: Phosphorous removal in steelmaking is favoured by basic slag

Reason r: Basic slag decreases the activity of  $P_2O_5$  in the slag

- (A) Both a and r are true and r is the correct reason for a  
 (B) Both a and r are false  
 (C) a is true but r is false  
 (D) Both a and r are true but r is not the correct reason for a

- Q.60 Given the following assertion 'a' and the reason 'r', the correct option is

Assertion a: In Bayer's process high pressure is used to dissolve alumina from bauxite

Reason r: Pressure increases the boiling point of water

- (A) Both a and r are correct, but r is not the correct reason for a  
 (B) Both a and r are false  
 (C) Both a and r are correct and r is the correct reason for a  
 (D) a is true but r is false

- Q.61 Match the alloys in Group 1 with the main precipitates responsible for hardening in Group 2

Group 1

- (P) Al-4.4%Cu-1.5%Mg-0.6%Mn  
 (Q) Fe-18.0%Ni-8.5%Co-3.5%Mo-0.2%Ti-0.1%Al  
 (R) Al-1.0%Mg-0.6%Si-0.3%Cu-0.2%Cr  
 (S) Ni-15.0%Cr-2.7%Al-1.7%Ti-1.0%Fe

- (A) P-3, Q-5, R-2, S-4  
 (C) P-4, Q-1, R-3, S-5

Group 2

- (1)  $Ni_3Mo$   
 (2)  $Mg_2Si$   
 (3)  $CuAl_2$   
 (4)  $TiAl_3$   
 (5)  $Ni_3Al$

- (B) P-1, Q-3, R-2, S-4  
 (D) P-3, Q-1, R-2, S-5

- Q.62 Identify the attributes associated with dispersion hardened alloys
- (P) dispersoids do not dissolve in the matrix even at high temperatures  
 (Q) dispersoids are coherent with the matrix  
 (R) dispersoids impart creep resistance to the alloy  
 (S) dispersoids improve the corrosion resistance of the alloy
- (A) P, S                      (B) Q, R                      (C) Q, S                      (D) P, R
- Q.63 In a gaseous mixture, CO, CO<sub>2</sub> and O<sub>2</sub> are in equilibrium at temperature T. For the reaction  $\text{CO} + 0.5\text{O}_2 = \text{CO}_2$ ,  $\Delta G^0 = -281,400 + 87.6T$  Joules. The correct statements among the following are
- (P) The reaction will shift to left on increasing T  
 (Q) The reaction will shift to right on increasing T  
 (R) The reaction will shift to left on increasing pressure  
 (S) The reaction will shift to right on increasing pressure
- (A) P, S                      (B) P, Q                      (C) Q, R                      (D) R, S
- Q.64 The casting processes that require expendable moulds are
- (P) investment casting  
 (Q) low-pressure casting  
 (R) shell moulding  
 (S) slush casting
- (A) P, Q                      (B) Q, R                      (C) R, S                      (D) P, R
- Q.65 Transport mechanisms that do NOT contribute to densification during sintering are
- (P) surface diffusion  
 (Q) grain boundary diffusion  
 (R) bulk diffusion  
 (S) evaporation-condensation  
 (T) viscous flow
- (A) P, Q                      (B) Q, S                      (C) Q, T                      (D) P, S
- Q.66 The order of decreasing weldability among the following steels is
- (P) Fe-0.6%C  
 (Q) Fe-0.4%C  
 (R) HSLA
- (A) R→Q→P                      (B) P→Q→R                      (C) Q→P→R                      (D) Q→R→P
- Q.67 Match the welding processes in Group 1 with the sources of heat in Group 2
- | <u>Group 1</u>         | <u>Group 2</u>            |
|------------------------|---------------------------|
| (P) Ultrasonic welding | (1) Thermochemical        |
| (Q) Spot welding       | (2) Electrical resistance |
| (R) SMAW               | (3) Friction              |
| (S) Thermit welding    | (4) Electrical arc        |
- (A) P-3, Q-2, R-1, S-4                      (B) P-4, Q-3, R-2, S-1  
 (C) P-1, Q-3, R-4, S-2                      (D) P-3, Q-2, R-4, S-1
- Q.68 A cup is to be made from a 2 mm thick metal sheet by deep-drawing. The height of the cup is 75 mm and the inside diameter is 100 mm. For a drawing ratio of 1.25, the blank diameter in mm is
- (A) 62.5                      (B) 125                      (C) 225                      (D) 250

Q.69 The defects that are NOT observed in extruded products are

- (P) chevron cracking
- (Q) fold
- (R) piping
- (S) surface cracking
- (T) alligatoring

(A) P, Q                      (B) R, T                      (C) P, S                      (D) Q, T

Q.70 Oil impregnated bronze bearings are manufactured using

- (A) pressure die casting
- (B) centrifugal casting
- (C) solid-state sintering
- (D) liquid phase sintering

### Common Data Questions

#### Common Data for Questions 71,72 and 73:

The diffusivities of carbon in  $\gamma$ -iron at 1173 and 1273 K are  $5.90 \times 10^{-12}$  and  $1.94 \times 10^{-11} \text{ m}^2\text{s}^{-1}$ , respectively.

Q.71 The activation energy for diffusion in  $\text{kJ mol}^{-1}$  is

- (A) 138                      (B) 148                      (C) 158                      (D) 168

Q.72 The diffusivity of carbon in  $\gamma$ -iron at 1373 K in  $\text{m}^2\text{s}^{-1}$  is

- (A)  $3.4 \times 10^{-11}$                       (B)  $4.4 \times 10^{-11}$                       (C)  $5.4 \times 10^{-11}$                       (D)  $6.4 \times 10^{-11}$

Q.73 During the carburization of a steel, a case depth of  $d$  has been obtained in 40 hours at 1173 K. For achieving a case depth of  $d/2$  at 1273 K, the time required in hours is

- (A) 1                      (B) 2                      (C) 3                      (D) 4

#### Common Data for Questions 74 and 75:

A copper alloy powder has an apparent density of  $3000 \text{ kg m}^{-3}$  and tap density of  $4500 \text{ kg m}^{-3}$ . The powder is compacted in a cylindrical die at 300 MPa to a green density of  $6000 \text{ kg m}^{-3}$ . Subsequently, the compact is sintered to a density of  $7500 \text{ kg m}^{-3}$ . The theoretical density of the alloy is  $9000 \text{ kg m}^{-3}$ .

Q.74 If the powder is compressed to 10 mm height, the initial fill height in mm is

- (A) 12                      (B) 15                      (C) 20                      (D) 25

Q.75 The densification parameter of the sintered compact is

- (A) 0.50                      (B) 0.67                      (C) 0.75                      (D) 0.83

### Linked Answer Questions: Q.76 to Q.85 carry two marks each.

#### Statement for Linked Answer Questions 76 and 77:

A polyester-matrix composite is unidirectionally reinforced with 60 vol.% of E-glass fibers. The elastic moduli of the matrix and the fiber are 6.9 and 72.4 GPa, respectively.

Q.76 The elastic modulus of the composite parallel to the fiber direction in GPa is

- (A) 15.1                      (B) 23.1                      (C) 43.4                      (D) 46.2

- Q.77 If a load of 100 kg is applied on the composite in the fiber direction, the load carried by the fibers in kg is
- (A) 6 (B) 47 (C) 94 (D) 100

**Statement for Linked Answer Questions 78 and 79:**

1000 kg of zinc concentrate of composition 78% ZnS and 22% inerts is roasted in a multiple hearth furnace. Roasting converts ZnS to ZnO, SO<sub>2</sub> and SO<sub>3</sub>. The exit gas contains 6 vol.% SO<sub>2</sub> and 2 vol.% SO<sub>3</sub>. Molecular weights: Zn = 65, S = 32, O<sub>2</sub> = 32  
Composition of air (in vol.%) = 21% O<sub>2</sub> and 79% N<sub>2</sub>  
1 kg mol of gas occupies 22.4 m<sup>3</sup> at 273 K and 1 atm

- Q.78 Volume of the exit gas (at 1 atm pressure and 273 K) in m<sup>3</sup> is
- (A) 2129 (B) 2252 (C) 2628 (D) 2923
- Q.79 Stoichiometric amount of air used (at 1 atm pressure and 273 K) in m<sup>3</sup> is
- (A) 1010 (B) 1394 (C) 1520 (D) 2020

**Statement for Linked Answer Questions 80 and 81:**

Density of Al = 2700 kg m<sup>-3</sup>, atomic weight of Al = 27, density of Al<sub>2</sub>O<sub>3</sub> = 3700 kg m<sup>-3</sup>.

- Q.80 The Pilling-Bedworth ratio for the oxidation of Al is
- (A) 0.57 (B) 0.74 (C) 1.38 (D) 3.12
- Q.81 The oxidation law that governs the high temperature oxidation of Al is
- (A) parabolic (B) linear (C) logarithmic (D) parilinear

**Statement for Linked Answer Questions 82 and 83:**

In the diffraction pattern of a fcc metal obtained using CuK<sub>α</sub> radiation (wavelength of 0.154 nm), a diffraction peak appears at 2θ of 58.4°. The lattice parameter of the crystal is 0.316 nm.

- Q.82 The interplanar spacing in nm is
- (A) 0.158 (B) 0.164 (C) 0.177 (D) 0.185
- Q.83 The Miller indices of the reflecting plane are
- (A) (111) (B) (200) (C) (220) (D) (222)

**Statement for Linked Answer Questions 84 and 85:**

Mg casting with a volume to surface area ratio (casting modulus) of 0.1 m is made by gravity die casting. Heat transfer coefficient at the metal-mould interface is 1.9 kJ m<sup>-2</sup> K<sup>-1</sup> s<sup>-1</sup>. The density and melting point of Mg are 1700 kg m<sup>-3</sup> and 923 K, respectively. Assume ambient temperature to be 293 K.

- Q.84 If the solidification time is 50 s, the latent heat of fusion in kJ mol<sup>-1</sup> is
- (A) 300 (B) 352 (C) 472 (D) 532
- Q.85 In a spiral channel of 10 mm diameter and with an entrance flow velocity of 300 mm s<sup>-1</sup>, the fluidity of the melt in mm is
- (A) 75 (B) 175 (C) 275 (D) 375

**END OF THE QUESTION PAPER**