## GA - General Aptitude

### Q1 - Q5 carry one mark each.

**Q.No. 1** He is known for his unscrupulous ways. He always sheds_____tears to deceive people.

(A) fox's
(B) crocodile's
(C) crocodile
(D) fox

**Q.No. 2** Jofra Archer, the England fast bowler, is_____than accurate.

(A) more fast
(B) faster
(C) less fast
(D) more faster

**Q.No. 3** Select the word that fits the analogy:

Build : Building :: Grow : _____

(A) Grown
(B) Grew
(C) Growth
(D) Growed

**Q.No. 4** I do not think you know the case well enough to have opinions. Having said that, I agree with your other point.
What does the phrase "having said that" mean in the given text?

(A) as opposed to what I have said
(B) despite what I have said
(C) in addition to what I have said
(D) contrary to what I have said

**Q.No. 5** Define $[x]$ as the greatest integer less than or equal to $x$, for each $x \in (-\infty, \infty)$. If $y = [x]$, then area under $y$ for $x \in [1,4]$ is _____.

(A) 1
(B) 3
(C) 4
(D) 6

### Q6 - Q10 carry two marks each.

**Q.No. 6** Crowd funding deals with mobilisation of funds for a project from a large number of people, who would be willing to invest smaller amounts through web-based platforms in the project.

Based on the above paragraph, which of the following is correct about crowd funding?

(A) Funds raised through unwilling contributions on web-based platforms.
(B) Funds raised through large contributions on web-based platforms.
(C) Funds raised through coerced contributions on web-based platforms.
(D) Funds raised through voluntary contributions on web-based platforms.

**Q.No. 7** P, Q, R and S are to be uniquely coded using α and β. If P is coded as αα and Q as αβ, then R and S, respectively, can be coded as ______.

(A) βα and αβ

(B) ββ and αα

(C) αβ and ββ

(D) βα and ββ

**Q.No. 8** The sum of the first $n$ terms in the sequence 8, 88, 888, 8888, … is______.

(A) $\frac{81}{80}(10^n - 1) + \frac{9}{8}n$

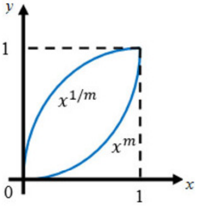
(B) $\frac{81}{80}(10^n - 1) - \frac{9}{8}n$

(C) $\frac{80}{81}(10^n - 1) + \frac{8}{9}n$

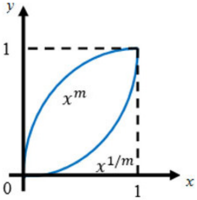
(D) $\frac{80}{81}(10^n - 1) - \frac{8}{9}n$

**Q.No. 9** Select the graph that schematically represents BOTH $y = x^m$ and $y = x^{1/m}$ properly in the interval $0 \le x \le 1$, for integer values of $m$, where $m > 1$.

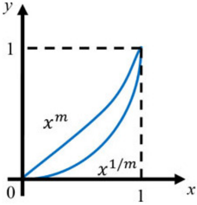
(A)



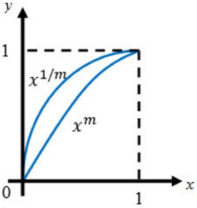
(B)



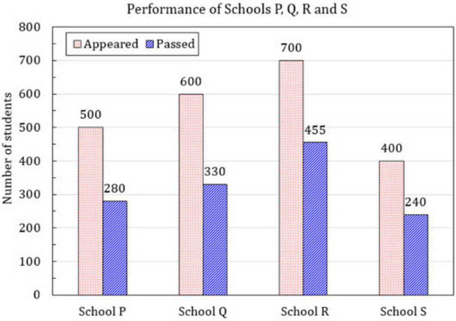
(C)



(D)



Q.No. 10 The bar graph shows the data of the students who appeared and passed in an examination for four schools P, Q, R and S. The average of success rates (in percentage) of these four schools is _____.



(A) 58.5 %

(B) 58.8 %

(C) 59.0 %

(D) 59.3 %

## MT: Metallurgical Engineering

## Q1 - Q25 carry one mark each.

Q.No. 1 The general solution to the following homogeneous ODE,

$$\frac{d^2y}{dt^2}+4\frac{dy}{dt}+3y=0,$$

is,

$$y(t)=c_1e^{\lambda_1 t}+c_2e^{\lambda_2 t}.$$

The values of $\lambda_1$ and $\lambda_2$ are:

(A) -1 and -3

(B) -3 and -3

(C) 1 and -3

(D) 1 and 3

**Q.No. 2** The number of independent elastic constants of an isotropic material is:

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

**Q.No. 3** A slip system consists of a slip plane and a slip direction. Which one of the following is NOT a valid slip system in a FCC copper crystal?

(A) $(111)[1\bar{1}0]$
(B) $(\bar{1}11)[011]$
(C) $(1\bar{1}1)[10\bar{1}]$
(D) $(11\bar{1})[101]$

**Q.No. 4** A dielectric material is:

(A) Electrical conductor
(B) Metallic magnet
(C) Two coupled electrical conductors
(D) Electrical insulator

**Q.No. 5** Which one of the following processes is an example of an electrolytic cell?

(A) Corrosion of a metal rod in ambient atmosphere
(B) Charging of a rechargeable battery
(C) Discharging of a rechargeable battery
(D) Sacrificial cathodic protection system

**Q.No. 6** Which one of the following statements regarding selective leaching of a binary alloy is TRUE?

(A) The lower atomic weight element is leached.
(B) The element having higher diffusivity is leached.
(C) The more electronegative element is leached.
(D) The element with lower density is leached.

**Q.No. 7** In green sand casting, which one of the following is NOT a part of the gating system?

(A) Runner
(B) Sprue
(C) Riser
(D) Pouring basin

**Q.No. 8** For a material to exhibit superplasticity, one of the requirements is:

(A) Coarse-grained microstructure
(B) High strain-rate sensitivity
(C) Low strain-hardening exponent
(D) High modulus of elasticity

**Q.No. 9** The dye penetrant test for detecting flaws is based on:

(A) Magnetism

(B) Sound propagation

(C) X-ray absorption

(D) Capillary action

**Q.No. 10** When 1 mole of $C_3H_8$ at 300 K is burnt with stoichiometric amount of oxygen at 300 K to form $CO_2$ and $H_2O$, the adiabatic flame temperature is 5975 K. If $C_3H_8$ is burnt under the same conditions but with excess oxygen, the adiabatic flame temperature will be

(A) equal to 5975 K irrespective of the amount of excess oxygen.

(B) higher than 5975 K irrespective of the amount of excess oxygen.

(C) lower than 5975 K irrespective of the amount of excess oxygen.

(D) higher or lower than 5975 K depending on the amount of excess oxygen.

**Q.No. 11** Two solid spheres X and Y of identical diameter are made of different materials having thermal diffusivities $100 \times 10^{-6}\, m^2 s^{-1}$ and $25 \times 10^{-6}\, m^2 s^{-1}$ respectively. Both spheres are heated in a furnace maintained at 1000 K. If the center of the sphere X reaches 800 K in 1 hour, time required for the center of sphere Y to reach 800 K is

(A) 1 hour.

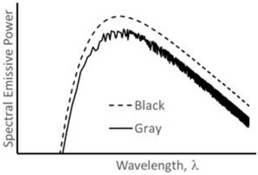
(B) 2 hours.

(C) 4 hours.

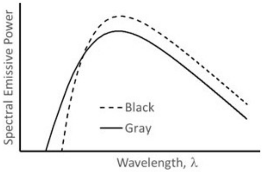
(D) 16 hours.

**Q.No. 12** Select the correct spectra (shown on a log-log scale in the figures) for emission from a gray surface and a black body, both maintained at 1000 K.

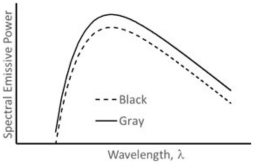
(A)



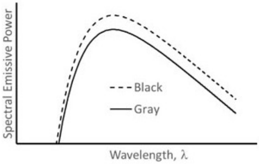
(B)



(C)



(D)



Q.No. 13 Given the three vectors $\mathbf{X} = -\mathbf{i} - \mathbf{j} + \mathbf{k}$, $\mathbf{Y} = -\mathbf{i} + 2\mathbf{j} + \mathbf{k}$ **and** $\mathbf{Z} = \mathbf{i} + \mathbf{k}$, which one of the following statements is TRUE?

(A) **X**, **Y** and **Z** are mutually perpendicular.

(B) **X**, **Y** and **Z** are coplanar.

(C) **X** makes an angle of 30° with the normal to the plane containing **Y** and **Z.**

(D) **Z** makes an angle of 60° with the normal to the plane containing **X** and **Y.**

Q.No. 14 Angle between two neighboring tetrahedral bonds in Si having a diamond cubic structure is:

(A) 102.5°

(B) 109.5°

(C) 120°

(D) 135.5°

Q.No. 15 The sequence of precipitation during aging of Al – 4 wt.% Cu alloy is:

(A) GP zone $\rightarrow \theta'' \rightarrow \theta' \rightarrow \theta$

(B) GP zone $\rightarrow \theta \rightarrow \theta' \rightarrow \theta''$

(C) GP zone $\rightarrow \theta' \rightarrow \theta'' \rightarrow \theta$

(D) $\theta'' \rightarrow \theta' \rightarrow$ GP zone $\rightarrow \theta$

Q.No. 16 The indenter used in Rockwell hardness measurements on C scale is

(A) diamond cone.

(B) 10 mm steel ball.

(C) diamond pyramid.

(D) 1/16-in. steel ball

Q.No. 17 For the function $y = a^x$, the derivative $\frac{dy}{dx}$ at $x = 1$ is:

(A) 1

(B) $a$

(C) $a^2$

(D) $a \ln a$

Q.No. 18 Cupola is a furnace used to produce

(A) cast irons.

(B) plain carbon steels.

(C) copper alloys.

(D) aluminium alloys.

Q.No. 19 The functions $y = e^x$ and $y = e^{-x}$ intersect at the point:

(A) (1, 3)

(B) (-2, 2)

(C) $(0, 1)$

(D) $(-1, -1)$

**Q.No. 20** A heavily cold-worked metal will

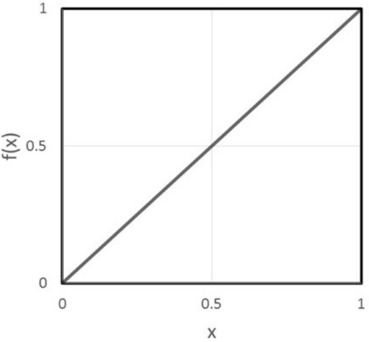
(A) yield a coarser recrystallized grain size.

(B) possess a lower driving force for recrytallization.

(C) have a higher energy barrier for nucleation of recrystallized grains.

(D) recrystallize at lower temperatures.

**Q.No. 21** For the function $f(x)$ given in the figure, the value of $\int_0^1 (1 - f(x))\, dx$ is _________ (round off to one decimal place).



**Q.No. 22** A component subjected to tensile stress in a mechanical device is monitored periodically for cracks by NDT. The NDT technique can only detect cracks (both surface and internal) which are larger than 1 mm. Keeping a 10% margin of safety, the maximum allowed tensile stress on the component will be _______ MPa (round off to the nearest integer).

Given, fracture toughness $K_{IC} = 30$ MPa $\mathrm{m}^{1/2}$ and assume crack geometry factor of unity.

**Q.No. 23** An iron plate with a total exposed surface area of 50 $\mathrm{cm}^2$ undergoes atmospheric corrosion. If 200 g of weight is lost over a period of 10 years, then the corrosion rate is ___________ $\mathrm{kg.m^{-2}.year^{-1}}$ (round off to the nearest integer).

**Q.No. 24** In cold-rolling, for the sheet to be drawn into rolls, the angle of contact (or angle of bite) should be less than or equal to ___________ degree (round off to one decimal place).

Given, the coefficient of friction between sheet and roll is 0.1

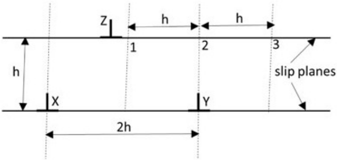
Q.No. 25 The number of atoms per unit area in (100) plane of Pb is ____________ $\mathrm{nm}^{-2}$ (round off to the nearest integer).

Given, crystal structure and atomic radius of Pb are FCC and 0.175 nm respectively.

## Q26 - Q55 carry two marks each.

Q.No. 26 In the edge dislocation configuration given in the figure, dislocations **X** and **Y** are fixed and separated by a distance *2h* on the same slip plane. Dislocation **Z** is free to glide on a parallel slip plane. The two slip planes are separated by a distance *h*. Which one of the following statements is TRUE regarding the stability of dislocation **Z** at positions 1, 2 and 3?

Assume all dislocations have identical Burgers vector.



(A) Position 1: unstable equilibrium; Position 2: unstable; Position 3: unstable

(B) Position 1: stable equilibrium; Position 2: unstable; Position 3: unstable

(C) Position 1: unstable equilibrium; Position 2: stable; Position 3: unstable

(D) Position 1: stable equilibrium; Position 2: unstable; Position 3: stable

Q.No. 27 Which one of the following dislocation reactions is NOT feasible in a FCC crystal?

(A) $\frac{1}{2}[0\bar{1}1] \rightarrow \frac{1}{6}[1\bar{2}1] + \frac{1}{6}[\bar{1}\bar{1}2]$

(B) $\frac{1}{2}[1\bar{1}0] + \frac{1}{2}[1\bar{1}0] \rightarrow [1\bar{1}0]$

(C) $\frac{1}{6}[11\bar{2}] + \frac{1}{3}[111] \rightarrow \frac{1}{2}[110]$

(D) $\frac{1}{2}[\bar{1}01] \rightarrow \frac{1}{6}[\bar{2}11] + \frac{1}{6}[\bar{1}\bar{1}2]$

Q.No. 28 A galvanic cell is formed by connecting Zn ($E^0_{Zn2+/Zn} = -0.76\ V$) and Fe ($E^0_{Fe2+/Fe} = -0.44\ V$) wires immersed in their respective ion solutions. The cell discharges spontaneously with a voltage of 0.5 V. The ratio of the concentration of $[Fe^{2+}]$ to $[Zn^{2+}]$ ions in the cell is of the order of:

Given, R = 8.314 $\mathrm{J.mol^{-1}.K^{-1}}$, F = 96500 $\mathrm{C.mol^{-1}}$, T = 298 K

(A) $10^{-6}$

(B) $10^{-5}$

(C) $10^{6}$

(D) $10^{7}$

Q.No. 29 The divergence of the vector field $(x^3 + y^3)\boldsymbol{i} + 3xy^2\boldsymbol{j} + 3zy^2\boldsymbol{k}$ is:

(A) $3y^2 + 6xy + 6x^2$

(B) $3x^2 + 6y^2 + 9xy + 6yz$

(C) $12xyz$

(D) $3(x + y)^2$

Q.No. 30 Match the products in **Column I** with the manufacturing processes in **Column II**.

| **Column I** | **Column II** |
|---|---|
| (P) Blades of a gas turbine | 1. Sand casting |
| (Q) Seamless tubing | 2. Extrusion |
| (R) Automotive cylinder blocks | 3. Powder metallurgy and wire drawing |
| (S) Tungsten filament | 4. Investment casting |

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

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

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

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

Q.No. 31 $f(x) = x\, ln(x) + (1 - x)\, ln(1 - x) + 3\, x\,(1 - x)$ has ________ at $x = 0.5$

(A) a local minimum

(B) a local maximum

(C) a point of inflection

(D) a non-zero slope

Q.No. 32 Match the processes in **Column I** with the most appropriate mechanisms in **Column II.**

| **Column I** | **Column II** |
|---|---|
| (P) Blast furnace iron making process | 1.Metallothermic reduction |
| (Q) Hall-Heroult's process | 2. Oxidation |
| (R) Basic oxygen furnace steel making process | 3. Carbothermic reduction |
| (S) Kroll's process | 4. Fused salt electrolysis |

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

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

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

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

Q.No. 33 Match the reactors in **Column I** with the corresponding products in **Column II.**

| **Column I** | **Column II** |
|---|---|
| (P) COREX | 1. Sponge iron |
| (Q) MIDREX | 2. Copper matte |
| (R) Flash smelting reactor | 3. Hot metal or pig iron |
| (S) Submerged arc furnace | 4. Ferrochrome |

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

Q.No. 34 X-ray diffraction pattern from an elemental metal with a FCC crystal structure shows the first peak at a Bragg angle $\theta = 24.65^{\circ}$. The lattice parameter of this metal is _______ nm.

Given, wavelength of the X-ray used is 0.1543 nm.

(A) 0.185
(B) 0.262
(C) 0.320
(D) 0.370

Q.No. 35 Match the materials in **Column I** with their common applications in **Column II**.

| **Column I** | **Column II** |
|---|---|
| (P) Gray iron | 1. Cladding for uranium fuel in nuclear reactor |
| (Q) Ductile iron | 2. Base structure of heavy machines |
| (R) Zirconium alloy | 3. Valves and pump bodies |
| (S) Beryllium-Copper alloy | 4. Jet aircraft landing gear bearings |

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

Q.No. 36 The Mg-Sn phase diagram exhibits two eutectics on either side of the high melting intermetallic line compound, $Mg_2Sn$, as given below.

At 561°C: $L\ (36.9\ \text{wt.\% Sn}) \rightarrow \alpha\ (14.48\ \text{wt.\% Sn}) + Mg_2Sn$

At 203°C: $L\ (97.87\ \text{wt.\% Sn}) \rightarrow \beta\text{-Sn}\ (\text{almost 100 wt.\% Sn}) + Mg_2Sn$

After the eutectic reaction has gone to completion and equilibrium has been attained at a temperature just below 561°C, the amount of eutectic constituent present in the alloy, Mg-50 wt.% Sn, is approximately _________ (in wt.%).

Given, atomic weight of Sn is 118.7 and Mg is 24.3

(A) 25
(B) 38
(C) 62
(D) 75

Q.No. 37 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r]

Assertion [a]: Low-alloy steels used for medium-temperature creep resistance often have additions of strong carbide-forming elements.

Reason [r]: During creep deformation, the particles with higher misfit with the matrix, lose coherency.

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

Q.No. 38 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r]

Assertion [a]: The rate of homogenization in a dilute substitutional solid solution of B in A is controlled by the diffusivity of B.

Reason [r]: Atomic migration cannot occur along dislocations and grain boundaries.

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

Q.No. 39 Match the elements in **Column I** with their electronic behaviour given in **Column II**.

| **Column: I** | **Column: II** |
|---|---|
| (P) Copper | 1. Ferromagnetic |
| (Q) Iron | 2. Superconducting |
| (R) Mercury | 3. Semiconducting |
| (S) Silicon | 4. Diamagnetic |

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

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

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

Q.No. 40 Radius of the largest interstitial atom that can be accommodated in an octahedral void in BCC iron without distorting the lattice is ________ nm (round off to three decimal places).

Assume hard sphere model and radius of Fe atom as 0.124 nm.

Q.No. 41 The production process of cylindrical pipes results in a statistical scatter in their diameter which is modelled by a normal distribution with a mean value of 10 mm. If the area under the normal curve between 9 mm and 10 mm is 0.35, then the probability of producing pipes of diameter greater than 11 mm is ______________ (round off to two decimal places).

Q.No. 42 The solution (using trapezoidal rule) of the integral

$$\int_0^1 e^{-x^2}\,dx$$

by dividing the range 0 to 1 into two equal intervals is ____________ (round off to two decimal places).

Q.No. 43 Iron is corroding in fresh water which has dissolved oxygen concentration of 15 mM. The anodic current density at an overpotential of 120 mV is ___________ $A.cm^{-2}$ (round off to three decimal places).

Given:

1. Anodic Tafel slope is 0.06 V.
2. Diffusion coefficient of oxygen is $2.42\times10^{-5}$ $cm^2.s^{-1}$.
3. Diffusion layer thickness is 0.06 cm.

Q.No. 44 A metal oxidizes at 1200 K with a parabolic rate constant of $3\times10^{-6}$ $g^2.cm^{-4}.s^{-1}$. Time taken for the oxide film to grow to a thickness of 2 μm is ___________ s (round off to two decimal places).

Given, density of oxide is 6.5 $g.cm^{-3}$.

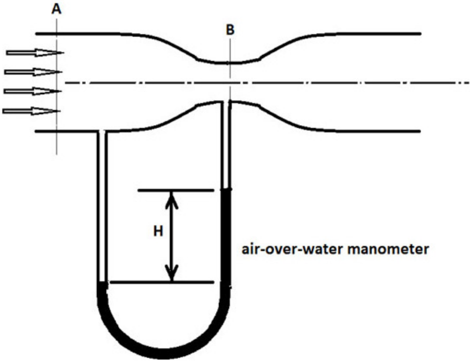
Q.No. 45 Two plates of composition, Fe–10 wt.% Ni and Fe–20 wt.% Cr–5 wt.% Ni are fusion-welded using a filler rod of composition 20 wt.% Ni–80 wt.% Cr. Contribution to dilution of the weld pool is 20% from each plate. The Ni content in the weld pool is ______ wt.% (round off to the nearest integer).

Q.No. 46 Figure shows schematic of a venturimeter. The cross sectional area is 100 $mm^2$ at

A and is 50 $mm^2$ at B. If air is flowing through the venturimeter at a flow rate of $10^{-3}$ $m^3.s^{-1}$, the height H in the air-over-water manometer is ________ mm (round off to the nearest integer).

Assume:

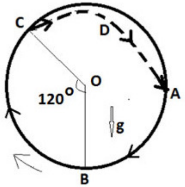
1. Incompressible flow with no friction losses.
2. Density of air is 1 kg $m^{-3}$.
3. Density of water is 1000 kg $m^{-3}$.
4. Acceleration due to gravity is 9.8 m $s^{-2}$.



**Q.No. 47** For effective communition in a ball mill, it is desired that the balls travelling along the mill wall leave the wall at point C and travel freely in air along the path CDA, as shown in the figure. If $\angle BOC$ is 120°, the rotational speed of the mill is ____________ rpm (rounded off to one decimal place) by performing suitable force balance at point C.

Assume:

1. There is no slip between the ball and mill wall.
2. O is the rotational axis of the mill and OB is parallel to the vector **g**.
3. Inner diameter of ball mill is 3.26 m.
4. Acceleration due to gravity g is 9.8 m $s^{-2}$.



**Q.No. 48** If liquid copper is cooled to 1353 K, magnitude of the driving force for liquid to transform to solid is ___________ $J.mol^{-1}$ (round off to one decimal place).

Given, melting temperature and enthalpy of melting of copper are 1356 K and 13 $kJ.mol^{-1}$ respectively.

**Q.No. 49** 1000 kg of liquid steel containing 0.03 wt.% S needs to be desulphurized using a slag to bring the sulphur content down to 0.015 wt.%. The quantity of slag needed is ____________ kg (round off to the nearest integer).

Assume:

1. Thermodynamic equilibrium
2. No sulphur in the slag prior to desulphurization treatment

Given the equilibrium sulphur partition ratio between slag and steel,

$$\frac{(wt.\%\,S)_{in\,slag}}{[wt.\%\,S]_{in\,steel}}$$ is 50.

**Q.No. 50** Zone refining of Si results in residual P content of 0.1 parts per billion by weight. The electrical conductivity of this zone refined Si is ________ $\Omega^{-1}.m^{-1}$ (round off to two decimal places).

Given:

1. Avogadro number is $6.02\times10^{23}$.
2. Density of Si is 2.33 $g.cm^{-3}$.
3. Atomic weight of P is 30.97.
4. Charge of electron is $1.6\times10^{-19}$ A.s
5. Mobility of electron is 0.2 $m^2.V^{-1}.s^{-1}$

**Q.No. 51** The steady state creep rate of a material increases by a factor of 20 when the temperature is increased from 890 K to 980 K. The creep rate at a temperature of ________ K (round off to the nearest integer) will be 5 times the creep rate at 890 K.

**Q.No. 52** Crack growth is being continuously measured in a test specimen subjected to constant amplitude cyclic stress with a mean stress of zero. The crack growth rate is related to the stress intensity range, $\Delta K$ as

$$\frac{da}{dN} \propto (\Delta K)^3 ,$$

where, a is the crack length and N is the number of cycles. When the crack length increases by a factor of two, the crack growth rate will increase by a factor of ____________ (round off to one decimal place).

**Q.No. 53** In a top gated mold, liquid metal enters the mold cavity as a freely falling stream under gravity from a height of 0.5 m. Ignore the fluid friction due to viscosity and the drag due to changes in the direction of flow. If the volume of the mold cavity is 10 $m^3$, then the time required to fill the mold is _________ s (round off to nearest integer).

Given:

1. Acceleration due to gravity is 9.8 $m.s^{-2}$.
2. Cross-sectional area of gate is 0.2 $m^2$.

**Q.No. 54** A Basic Oxygen Furnace operator, at the end of oxygen blow, measures the dissolved oxygen content in the steel as 0.03 wt.% and the steel temperature as 1800 K. The carbon content [C] in the steel is ___________ wt.% (round off to two decimal places).

Assume:

1) Equilibrium between dissolved carbon [C], dissolved oxygen [O], and CO (gas) at 1 atmosphere.
2) Henry's law is valid for both [C] and [O]

Given:

$$[C]_{1\,wt.\%\,Henrian\,Std.\,State} + [O]_{1\,wt.\%\,Henrian\,Std.\,State} \rightarrow (CO)_{1\,atm.\,Std.\,State}$$

$$\Delta G^o = -19840 - 40.65\,T \;\; \text{J}$$

$R = 8.314\ J.mol^{-1}.K^{-1}$

**Q.No. 55** **M** and **N** are 3 × 3 matrices. If the det(**M**) is –9 and the det(**N**) is –14, then the det(**NM**) is ___________ (round off to the nearest integer).