

XE : ENGINEERING SCIENCES

Duration: Three Hours

Maximum Marks: 100

Read the following instructions carefully.

- Write your name and registration number in the space provided at the bottom of this page.
- Take out the **Optical Response Sheet (ORS)** from this Question Booklet **without breaking the seal**.
- Do not open the seal of the Question Booklet until you are asked to do so by the invigilator.
- Write your registration number, your name and name of the examination centre at the specified locations on the right half of the **ORS**. Also, using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters corresponding to your test paper code (XE).
- This Question Booklet contains **36** pages including blank pages for rough work. After opening the seal at the specified time, please check all pages and report discrepancy, if any.
- You can answer a maximum of 65 questions carrying 100 marks. Questions must be answered on the left hand side of the **ORS** by darkening the appropriate bubble (marked A, B, C, D) using HB pencil against the question number. **For each question darken the bubble of the 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 an incorrect response.
- This Question Booklet contains **Eight** sections as listed below.

Section	Page No.	Section	Page No.
GA: General Aptitude	02	D. Solid Mechanics	16
A. Engineering Mathematics	04	E. Thermodynamics	21
B. Fluid Mechanics	07	F. Polymer Science & Engineering	25
C. Material Science	12	G. Food Technology	29

- Section GA (General Aptitude) and Section A (Engineering Mathematics) are compulsory. Choose **two** more sections from the remaining sections with codes **B** through **G**. Using HB pencil, mark the codes of the sections you have chosen by darkening the appropriate bubbles on the left hand side of the **ORS** provided. **Make sure you have correctly bubbled the codes of the sections you have chosen. ORS will not be evaluated if this information is NOT marked.**
- There are 10 questions carrying 15 marks in General Aptitude (GA) section, which is compulsory. Questions Q.1–Q.5 carry 1-mark each, and questions Q.6–Q.10 carry 2-marks each.
- There are 11 questions carrying 15 marks in Section A (Engineering Mathematics), which is compulsory. Questions Q.1–Q.7 carry 1-mark each and questions Q.8–Q.11 carry 2-marks each.
- Each of the other sections (Sections B through G) contains 22 questions carrying 35 marks. Questions Q.1–Q.9 carry 1-mark each and questions Q.10–Q.22 carry 2-marks each. Questions Q.17–Q.20 (2 pairs) are common data questions. Questions Q.21 and Q.22 (1 pair) are linked answer questions. The answer to the second question of the pair of linked answer questions depends on the answer to the first question of the pair. If the first question in the linked pair is wrongly answered or is unattempted, then the answer to the second question in the pair will not be evaluated.
- Unattempted questions will result in zero marks and wrong answers will result in **NEGATIVE** marks. In GA, for Q.1–Q.5, $\frac{1}{3}$ mark will be deducted for each wrong answer and for Q.6–Q.10, $\frac{2}{3}$ mark will be deducted for each wrong answer. In Section A, for Q.1 – Q.7, $\frac{1}{3}$ mark will be deducted for each wrong answer and for Q.8–Q.11, $\frac{2}{3}$ mark will be deducted for each wrong answer. In all other section papers (Sections B through G), for Q.1–Q.9, $\frac{1}{3}$ mark will be deducted for each wrong answer and for Q.10–Q.20, $\frac{2}{3}$ mark will be deducted for each wrong answer. The question pair (Q.21, Q.22) is questions with linked answers. There will be negative marks only for wrong answer to the first question of the linked answer question pair i.e., for Q.21, $\frac{2}{3}$ mark will be deducted for wrong answer. There is no negative mark for Q.22.
- Calculator is allowed whereas charts, graph sheets or tables are **NOT** allowed in the examination hall.

Name							
Registration Number	XE						

C : MATERIAL SCIENCE

Useful Data

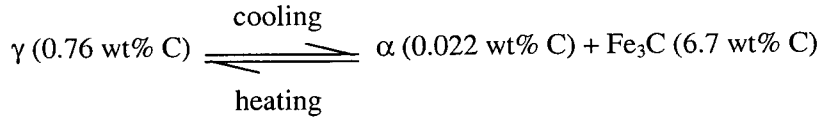
Boltzmann's constant	:	$1.38 \times 10^{-23} \text{ J K}^{-1}$
Electron charge	:	$1.602 \times 10^{-19} \text{ C}$
Gas constant	:	$8.314 \text{ J mol}^{-1} \text{ K}^{-1}$
1 J = 6.242×10^{18} eV		
Atomic weight (kg mol^{-1})		
Hydrogen		0.0010
Carbon		0.0120
Chlorine		0.0355

Q.1 – Q.9 carry one mark each.

- Q.1 Which one of the following pairs of crystal structures can have the same packing fraction of 0.74?
 (A) FCC and BCC (B) HCP and BCC (C) FCC and HCP (D) BCC and BCT [Nptel Reference 1](#)
- Q.2 Which one of the following is **NOT CORRECT**? [Nptel Reference 2](#)
 (A) An edge dislocation can cross slip (B) An edge dislocation can glide
 (C) A screw dislocation can cross slip (D) An edge dislocation can climb [Nptel Reference](#)
- Q.3 Which one of the following is **NOT CORRECT**? [Nptel Reference](#)
 (A) Working of lead at 25°C is hot working (B) Working of tungsten at 1000°C is hot working
 (C) Working of lead at -100°C is cold working (D) Working of tungsten at 25°C is cold working
[Nptel Reference1](#)
- Q.4 Which one of the following is **NOT** a ceramic? [Nptel Reference2](#)
 (A) SiC (B) MgO (C) TiB₂ (D) TiAl [Nptel Reference3](#)
[OR Nptel Reference 4](#)
- Q.5 If the average degree of polymerisation of a polyvinyl chloride (PVC) polymer is 2000, then its average molecular weight (in g mol^{-1}) is [Nptel Reference](#)
 (A) 125000 (B) 119000 (C) 56000 (D) 2000
- Q.6 Which one of the following materials has the lowest coefficient of thermal expansion? [Nptel Reference](#)
 (A) Superalloy (B) Super Invar (C) Spinel (D) α -brass
- Q.7 The colour of a metal is determined by the wavelength distribution of the radiation that is
 (A) diffracted (B) transmitted (C) reflected (D) refracted
- Q.8 Nickel ferrite is [Nptel Reference](#)
 (A) antiferromagnetic (B) ferromagnetic (C) diamagnetic (D) ferrimagnetic
- Q.9 The oxide scale responsible for the excellent corrosion resistance of stainless steels is [Nptel Reference1](#)
 (A) Cr₂O₃ (B) NiO (C) Fe₂O₃ (D) Al₂O₃ [Nptel Reference 2](#)

Q.10 - Q.22 carry two marks each.

- Q.10 A plain carbon steel was annealed just above the eutectoid temperature. Microstructural analysis revealed that the proeutectoid ferrite content was 30 wt%. The eutectoid reaction in the iron-iron carbide phase diagram is given below:



The carbon content of the steel (in wt%) is

- (A) 0.24 (B) 0.34 (C) 0.44 (D) 0.54

[Nptel Reference](#)

- Q.11 Match the materials in **Column-I** with the descriptions in **Column-II**.

Column-I

- P. Zirconia
Q. Cubic boron nitride
R. Hafnium carbide
S. Yttrium aluminium garnet

Column-II

1. Ultra-hard material
2. High temperature superconductor
3. Transformation toughening
4. Ultra-high temperature material
5. Host material for laser
6. Micro-crack toughening

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

- (B) P-6, Q-1, R-4, S-2
(D) P-4, Q-6, R-1, S-5

- Q.12 Match the materials in **Column-I** with the descriptions in **Column-II**.

Column-I

- P. Polyacrylonitrile
Q. Nylon-6,6
R. Polytetrafluoroethylene (PTFE)
S. Ebonite

Column-II

1. Hard and brittle material
2. Very high temperature resistant polymer
3. H-bonding
4. Acrylic fibre
5. Rubber
6. Polyester fibre

- (A) P-6, Q-3, R-2, S-1
(C) P-4, Q-2, R-6, S-5

- (B) P-2, Q-6, R-4, S-5
(D) P-4, Q-3, R-2, S-1

[Nptel Reference 1](#)

[Nptel Reference 2](#)

[Nptel Reference 3](#)

- Q.13 Match the techniques in **Column-I** with the descriptions in **Column-II**.

Column-I

- P. Differential scanning calorimetry
Q. Atomic force microscopy
R. Scanning electron microscopy
S. X-ray diffraction

Column-II

1. Residual stress measurement
2. Surface morphology of a material
3. Incident beam passes through a thin sample
4. Thermal expansion measurement
5. Resolution less than 1 nm is possible
6. Measurement of enthalpy change

- (A) P-6, Q-5, R-2, S-1
(C) P-4, Q-1, R-3, S-2

- (B) P-4, Q-5, R-2, S-1
(D) P-6, Q-1, R-5, S-3

[Nptel Reference](#)

Q.14 Match the properties in **Column-I** with the appropriate units in **Column-II**.

Column-I

- P. Thermal conductivity
 Q. Dielectric strength
 R. Magnetic permeability
 S. Capacitance

Column-II

1. H m^{-1}
 2. Wb m^{-2}
 3. $\text{W m}^{-1} \text{K}^{-1}$
 4. V m^{-1}
 5. C V^{-1}
 6. $\text{J mol}^{-1} \text{K}^{-1}$

(A) P-6, Q-4, R-2, S-5

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

Nptel Reference 1

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

(D) P-6, Q-5, R-1, S-4

Nptel Reference 2

Nptel Reference 3

Q.15 It takes 4 h for carburising a steel at 900°C . If the same carburising is to be accomplished in 2 h, what should be the temperature? The activation energy of diffusion of carbon in the steel is 151 kJ mol^{-1} .

(A) 850°C (B) 955°C (C) 1015°C (D) 1228°C

Nptel Reference

Q.16 A steel specimen (12 mm diameter and 60 mm length) undergoes elastic deformation under tension. The deformed specimen experiences a longitudinal strain of 0.001. If the Poisson's ratio is 0.3, the diameter of the deformed specimen (in mm) is

(A) 12.0120

(B) 12.0036

(C) 11.9964

(D) 11.9880

Nptel Reference

Common Data Questions**Common Data for Questions 17 and 18:**

The first peak in the powder X-ray diffraction pattern of an FCC metal appears at a Bragg angle of 19.2° . The wavelength of Cu-K_α radiation used is 0.154 nm .

Q.17 The lattice parameter of the metal (in nm) is

(A) 0.4505

(B) 0.4055

(C) 0.3505

(D) 0.3055

Nptel Reference 1

Nptel Reference 2

Q.18 The full width at half maximum (FWHM) of the first peak is 0.35° . Ignoring micro-strain and instrumental broadening, the crystallite size of the sample (in nm) is

(A) 20

(B) 24

(C) 200

(D) 240

Nptel Reference 1

Nptel Reference 2

Common Data for Questions 19 and 20:

For an intrinsic semiconductor, the mobilities of free electrons and holes are $0.14 \text{ m}^2\text{V}^{-1}\text{s}^{-1}$ and $0.038 \text{ m}^2\text{V}^{-1}\text{s}^{-1}$, respectively. Its bandgap is 1.107 eV and electrical conductivity at 300 K is $3.99 \times 10^{-4} \Omega^{-1}\text{m}^{-1}$.

Q.19 The free electron concentration (in m^{-3}) at 300 K is

(A) 13.99×10^{15} (B) 27.98×10^{15} (C) 13.99×10^{17} (D) 27.98×10^{17}

Nptel Reference

Q.20 What is the temperature at which the conductivity of the semiconductor is $0.399 \Omega^{-1}\text{m}^{-1}$?

(A) 343 K

(B) 443 K

(C) 493 K

(D) 543 K

Nptel Reference

Linked Answer Questions**Statement for Linked Answer Questions 21 and 22:**

A continuous and aligned glass fibre reinforced composite has a modulus of elasticity of 150 GPa in the longitudinal direction. The matrix is a polyester resin with a modulus of 4.5 GPa. The glass fibre has a modulus of 340 GPa.

Q.21 The volume fraction of the glass fibres is

(A) 0.398

(B) 0.434

(C) 0.497

(D) 0.566

[Nptel Reference 1](#)

[Nptel Reference 2](#)

Q.22 If the cross-sectional area of the composite is 300 mm^2 , and a stress of 100 MPa is applied in the longitudinal direction, what will be the total load (in kN) carried by the glass fibres?

(A) 0.5

(B) 5

(C) 20.5

(D) 29.5

[Nptel Reference 1](#)

[Nptel Reference 2](#)

END OF SECTION - C