XE : ENGINEERING SCIENCES

Duration: Three Hours *Maximum Marks*: 100

Read the following instructions carefully.

1. Do not open the seal of the Question Booklet until you are asked to do so by the invigilator.
2. Take out the **O**ptical **R**esponse **S**heet (**ORS)** from this Question Booklet **without breaking the seal** and read the instructions printed on the **ORS** carefully.
3. On the right half of the **ORS,** using ONLY a **black ink ball point pen**, (i) darken the bubble corresponding to your test paper code and the appropriate bubble under each digit of your registration number and (ii) write your registration number, your name and name of the examination centre and put your signature at the specified location.
4. This Question Booklet contains **36** pages including blank pages for rough work. After you are permitted to open the seal, please check all pages and report discrepancies, if any, to the invigilator.
5. There are a total of 65 questions carrying 100 marks. All these questions are of objective type. Each question has only **one** correct answer. Questions must be answered on the left hand side of the **ORS** by darkening the appropriate bubble (marked A, B, C, D) using ONLY a **black ink ball point pen** against the question number. **For each question darken the bubble of the correct answer**. More than one answer bubbled against a question will be treated as an incorrect response.
6. Since bubbles darkened by the black ink ball point pen **cannot** be erased, candidates should darken the bubbles in the **ORS very carefully.**
7. This Question Booklet contains **Eight** sections: **GA** (General Aptitude), **A** (Engineering Mathematics), **B** (Fluid Mechanics), **C** (Materials Science), **D** (Solid Mechanics), **E** (Thermodynamics), **F** (Polymer Science & Engineering) and **G** (Food Technology).
8. Section **GA** (General Aptitude) and Section **A** (Engineering Mathematics) are compulsory. Attempt any **two** optional sections **B** through **G**. Using a **black ink ball point pen**, mark the sections you have chosen by darkening the appropriate bubbles provided on the left hand side of the **ORS**. Also, write the codes of the optional sections in the boxes provided. In case the candidate **does not bubble section codes** corresponding to Optional Section-1 or Optional Section-2 or both, the corresponding sections **will NOT be evaluated**.
9. Questions Q.1 – Q.10 belong to Section **GA** (General Aptitude) and carry a total of 15 marks. Questions Q.1 – Q.5 carry 1 mark each, and questions Q.6 – Q.10 carry 2 marks each.
10. 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.
11. 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. The 2 marks questions include two pairs of common data questions and one pair of linked answer questions. The answer to the second question of the 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.
12. Unattempted questions will result in zero mark and wrong answers will result in **NEGATIVE** marks. For all 1 mark questions, ⅓ mark will be deducted for each wrong answer. For all 2 marks questions, ⅔ mark will be deducted for each wrong answer. However, in the case of the linked answer question pair, there will be negative marks only for wrong answer to the first question and no negative marks for wrong answer to the second question.
13. Calculator is allowed whereas charts, graph sheets or tables are **NOT** allowed in the examination hall.
14. Before the start of the examination, write your name and registration number in the space provided below using a black ink ball point pen.

Name								
Registration Number	**XE**							

C : MATERIALS SCIENCE

Useful data

Boltzmann's constant	: 1.38×10^{-23} J K^{-1}
Charge on an electron	: 1.602×10^{-19} C
Gas Constant	: 8.314 J mol^{-1} K^{-1}
Electron rest mass	: 9.1×10^{-31} kg
Permittivity of vacuum (ε_o)	: 8.854×10^{-12} F m^{-1}
Bohr Magneton	: 9.274×10^{-24} A/m^2

Q. 1 – Q. 9 carry one mark each.

Q.1 Which of the following is **NOT** a Bravais lattice?

(A) Simple tetragonal
(B) Body centred tetragonal
(C) Base centred orthorhombic
(D) Face centred tetragonal

Nptel Reference

Q.2 A Schottky defect in an ionic crystal is a stochiometric defect of

(A) Cation vacancy
(B) Anion vacancy
(C) Cation and anion vacancy
(D) Cation and anion interstitial

Nptel Reference

Q.3 Which of the following techniques is **NOT** used to grow single crystals of semiconductors? Nptel Reference 1

(A) Calendering (B) Czochralski (C) Float zone (D) Bridgman Nptel Reference 2

Q.4 Which of the following signals is produced due to the elastic scattering of electrons by a material?

(A) Secondary electron
(B) Backscattered electron
(C) Auger electron
(D) Photoelectron

Nptel Reference

Q.5 The best magnetostrictive material is

(A) $Nd_2Fe_{14}B$ (B) Fe_3O_4 (C) Cu_2MnAl (D) $ZnFe_2O_4$ Nptel Reference

Q.6 Of the following materials, which is the most suitable for an LED emitting at around 380 nm?

(A) Direct bandgap material with a small bandgap
(B) Indirect bandgap material with a large bandgap
(C) Direct bandgap material with a large bandgap
(D) Indirect bandgap material with a small bandgap

Nptel Reference

Q.7 Which material has the lowest specific heat capacity at room temperature?

(A) Water (B) Mercury (C) Copper (D) Silver

Q.8 Microstrain can be measured by X-ray diffraction using peak

(A) Area and intensity
(B) Position and area
(C) Broadening and intensity
(D) Position and broadening

Nptel Reference

Q.9 The Pilling-Bedworth ratio is defined as the ratio of

(A) Volume of oxide to volume of metal
(B) Weight of oxide to weight of metal
(C) Density of oxide to density of metal
(D) Surface area of oxide to surface area of metal

Nptel Reference

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

Q.10 Match the properties in **Column I** with the appropriate units in **Column II**

Column I	**Column II**
P. Thermal diffusivity	1. Hm^{-1}
Q. Fracture toughness	2. m^2s^{-1}
R. Surface energy	3. Fm^{-1}
S. Magnetic permeability	4. $Nm^{-3/2}$
	5. Jm^{-2}

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

Q.11 Match the characterization techniques in **Column I** with the options in **Column II**

Column I	**Column II**
P. Scanning tunneling microscopy	1. No vacuum required
Q. Scanning electron microscopy	2. Backscattered electrons
R. Transmission electron microscopy	3. Photoelectrons
S. Atomic force microscopy	4. Atomically sharp tip
	5. Sub-Angstrom resolution

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

Nptel Reference 1

Nptel Reference 2

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

Column I	**Column II**
P. Titanium diboride	1. Photocatalyst
Q. Molybdenum disilicide	2. Furnace heating element
R. Hydroxyapatite	3. Ultra high temperature material
S. Nanocrystalline titanium oxide	4. Tough ceramic
	5. Artificial bone implant

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

Nptel Reference

Q.13 Match the properties in **Column I** with the options in **Column II**

Column I	**Column II**
P. Toughness	1. Resistance to plastic deformation
Q. Resilience	2. Time dependent permanent deformation under constant load
R. Creep	3. Total elongation at failure
S. Hardness	4. Area under the stress-strain curve
	5. Area under the elastic part of the stress-strain curve

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

Nptel Reference 1

Nptel Reference 2

Q.14 Determine the mole fraction of vinyl chloride in a copolymer of vinyl chloride (CH_2CHCl) and vinyl acetate (CH_2-CH-$OCOCH_3$) having molecular weight of 10520 g/mol and degree of polymerization of 160.

Nptel Reference

(A) 0.14 (B) 0.30 (C) 0.70 (D) 0.86

Q.15 The electron concentration in an n-type semiconductor is $5 \times 10^{18}/m^3$. If the drift velocity of electrons is 100 m/s in an electric field of 500 V/m, calculate the conductivity of the semiconductor.

(A) 0.16×10^{-1} S/m (B) 1.60×10^{-1} S/m (C) 2.50×10^{-1} S/m (D) 30.05×10^{-1} S/m Nptel Reference

Q.16 Calculate the saturation magnetization (M_{sat}) for bcc iron of lattice parameter 2.866 Å.

(A) 0.79×10^6 A/m (B) 1.5×10^6 A/m (C) 3.15×10^6 A/m (D) 4.73×10^6 A/m Nptel Reference

Common Data Questions

Common Data for Questions 17 and 18: A plain 0.45 wt.% carbon steel is cooled slowly from 900°C to just below the eutectoid temperature (723°C) so that the following reaction occurs:

γ (0.8 wt.% C) $\leftrightarrow$ α (0.02 wt.% C) + Fe_3C (6.67 wt.% C)

Q.17 During cooling from 900°C to 723°C, the proeutectoid α forms from γ. Find the volume % of proeutectoid α just below 723°C for the steel.

(A) 44.9% (B) 66.1% (C) 55.1% (D) 34.9% Nptel Reference

Q.18 Find the volume % of pearlite for the steel just below 723°C for 0.45 wt.% carbon steel.

(A) 44.9% (B) 55.1% (C) 40.9% (D) 59.1% Nptel Reference

Common Data for Questions 19 and 20: A 20 kN tensile load is applied axially to a steel bar of cross-sectional area 8 cm^2 and 1m length. The Young's modulus of steel (E_{steel}) is 200 GPa, and of aluminium (E_{Al}) is 70 GPa. The Poisson's ratio (ν) can be taken as 0.3.

Q.19 When the same load is applied to an aluminium bar, it is found to give same elastic strain as the steel. Calculate the cross-sectional area of the aluminium bar.

(A) 11.43 cm^2 (B) 14.93 cm^2 (C) 18.26 cm^2 (D) 22.86 cm^2 Nptel Reference

Q.20 Calculate the final area of the steel bar after the deformation under the applied load of 20 kN.

(A) 7.9 cm^2 (B) 9.7 cm^2 (C) 7.0 cm^2 (D) 8.1 cm^2 Nptel Reference

Linked Answer Questions

Statement for Linked Answer Questions 21 and 22: Chromium has the bcc structure with atomic diameter of 2.494 Å.

Q.21 Calculate the lattice parameter of chromium assuming tight atomic bonding.

(A) 1.442 Å (B) 2.880 Å (C) 4.323 Å (D) 5.764 Å Nptel Reference

Q.22 Find the first diffraction peak position (2θ) for Cu Kα radiation with a wavelength of 1.54 Å

(A) 21.76^o (B) 33.05^o (C) 44.43^o (D) 66.10^o Nptel Reference

END OF SECTION - C