

XE : ENGINEERING SCIENCES

Duration: Three Hours

Maximum Marks:100

Please read the following instructions carefully:

General Instructions:

1. Total duration of examination is 180 minutes (3 hours).
2. The clock will be set at the server. The countdown timer in the top right corner of screen will display the remaining time available for you to complete the examination. When the timer reaches zero, the examination will end by itself. You will not be required to end or submit your examination.
3. The Question Palette displayed on the right side of screen will show the status of each question using one of the following symbols:



You have not visited the question yet.



You have not answered the question.



You have answered the question.



You have NOT answered the question, but have marked the question for review.



You have answered the question, but marked it for review.

The Marked for Review status for a question simply indicates that you would like to look at that question again. ***If a question is answered and Marked for Review, your answer for that question will be considered in the evaluation.***

Navigating to a Question

4. To answer a question, do the following:
 - a. Click on the question number in the Question Palette to go to that question directly.
 - b. Select an answer for a multiple choice type question. Use the virtual numeric keypad to enter a number as answer for a numerical type question.
 - c. Click on **Save and Next** to save your answer for the current question and then go to the next question.
 - d. Click on **Mark for Review and Next** to save your answer for the current question, mark it for review, and then go to the next question.
 - e. **Caution: Note that your answer for the current question will not be saved, if you navigate to another question directly by clicking on its question number.**
5. You can view all the questions by clicking on the **Question Paper** button. Note that the options for multiple choice type questions will not be shown.

Answering a Question

6. Procedure for answering a multiple choice type question:
 - a. To select your answer, click on the button of one of the options
 - b. To deselect your chosen answer, click on the button of the chosen option again or click on the **Clear Response** button
 - c. To change your chosen answer, click on the button of another option
 - d. To save your answer, you MUST click on the **Save and Next** button

- e. To mark the question for review, click on the **Mark for Review and Next** button. *If an answer is selected for a question that is Marked for Review, that answer will be considered in the evaluation.*
7. Procedure for answering a numerical answer type question:
 - a. To enter a number as your answer, use the virtual numerical keypad
 - b. A fraction (eg., -0.3 or -.3) can be entered as an answer with or without '0' before the decimal point
 - c. To clear your answer, click on the **Clear Response** button
 - d. To save your answer, you **MUST** click on the **Save and Next** button
 - e. To mark the question for review, click on the **Mark for Review and Next** button. *If an answer is entered for a question that is Marked for Review, that answer will be considered in the evaluation.*
8. To change your answer to a question that has already been answered, first select that question for answering and then follow the procedure for answering that type of question.
9. Note that **ONLY** Questions for which answers are saved or marked for review after answering will be considered for evaluation.

Choosing an Optional Section

10. Sections in this question paper are displayed on the top bar of the screen. Questions in a Section can be viewed by clicking on the name of that Section. The Section you are currently viewing is highlighted.
11. A checkbox is displayed for every optional Section in the Question Paper. To select an optional Section for answering, click on the checkbox for that Section.
12. If the checkbox for an optional Section is not selected, the **Save and Next** button and the **Mark for Review and Next** button will **NOT** be enabled for that Section. You will be able to only see questions in the Section, but you will not be able to answer questions in the Section.
13. After clicking the **Save and Next** button for the last question in a Section, you will automatically be taken to the first question of the next Section in sequence.
14. You can move the mouse cursor over the name of a Section to view the answering status for that Section.

Changing the Optional Section

15. After answering the chosen optional Sections, partially or completely, you can change an optional Section by selecting a checkbox for a new Section that you want to attempt. A warning message will appear along with a table showing the number of questions answered in each of the previously chosen optional Sections and a checkbox against each of these Sections. Click on a checkbox against a Section that you want to reset and then click on the **RESET** button. **Note that RESETING a Section will DELETE all the answers for questions in that Section. Hence, if you think that you may want to select this Section again later, you will have to note down your answers for questions in that Section.** If you do not want to reset any Section and want to continue answering the previously chosen optional Sections, then click on the **BACK** button.
16. If you deselect the checkbox for an optional Section in the top bar, the following warning message will appear: "Deselecting the checkbox will DELETE all the answers for questions in this Section. Do you want to deselect this Section?" If you want to deselect, click on the **RESET** button. If you do not want to deselect, click on the **BACK** button.
17. You can shuffle between different Sections any number of times. You can change the optional Sections any number of times.

Paper specific instructions:

1. There are a total of 65 questions carrying 100 marks. The question paper consists of questions of multiple choice type and numerical answer type. Multiple choice type questions will have four choices for the answer with only **one** correct choice. For numerical answer type questions, the answer is a number and no choices will be given. **A number as the answer should be entered** using the virtual keyboard on the monitor.
2. There are **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).
3. Section **GA** (General Aptitude) and Section **A** (Engineering Mathematics) are compulsory. Attempt any **two** optional Sections **B** through **G**.
4. 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.
5. 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.
6. 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 not attempted, then the answer to the second question in the pair will not be evaluated
7. Questions not attempted will result in zero mark. Wrong answers for multiple choice type questions will result in **NEGATIVE** marks. For all 1 mark questions, $\frac{1}{3}$ mark will be deducted for each wrong answer. For all 2 marks questions, $\frac{2}{3}$ 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. There is no negative marking for questions of numerical answer type.
8. Calculator is allowed. Charts, graph sheets or tables are **NOT** allowed in the examination hall.
9. Do the rough work in the Scribble Pad provided.

C: MATERIALS SCIENCE

Useful Data:

Avogadro's Number	: $6.023 \times 10^{23} \text{ mol}^{-1}$
Boltzmann's constant, k	: $1.38 \times 10^{-23} \text{ J.K}^{-1}$
Electron Charge, e	: $1.6 \times 10^{-19} \text{ C}$
Electron rest mass, m_o	: $9.1 \times 10^{-31} \text{ kg}$
Gas Constant, R	: $8.314 \text{ J.mol}^{-1}\text{K}^{-1}$
Free Space Permittivity, ϵ_o	: $8.854 \times 10^{-12} \text{ F.m}^{-1}$
Free Space magnetic permeability, μ_o	: $4\pi \times 10^{-7} \text{ H.m}^{-1}$
Speed of light, c	: $3 \times 10^8 \text{ m.s}^{-1}$
Planck's constant, h	: $6.63 \times 10^{-34} \text{ J.s}^{-1}$
Bohr Magneton, μ_b	: $9.27 \times 10^{-24} \text{ A m}^2$
1 eV = $1.6 \times 10^{-19} \text{ J}$	
1 calorie = 4.2 J	

Q. 1 – Q. 9 carry one mark each.

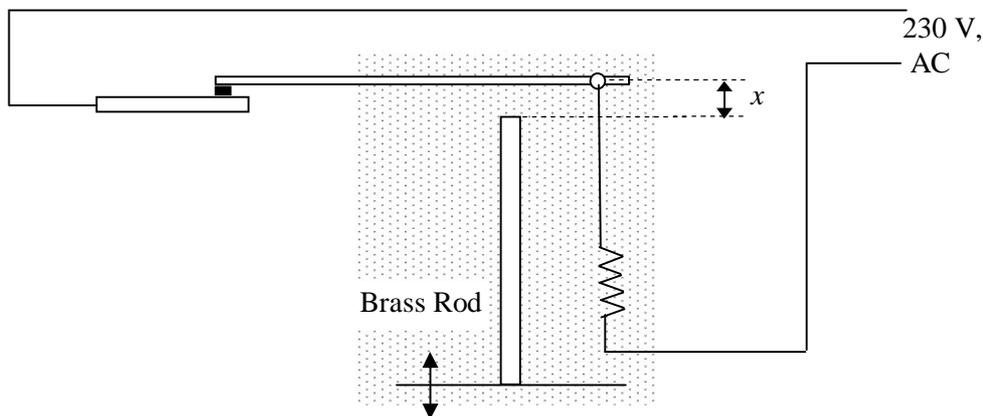
- Q.1 As temperature increases, diffusivity of an atom in a solid material, Nptel Reference 1
 (A) increases (B) decreases Nptel Reference 2
 (C) remains constant (D) depends on the specific material Nptel Reference 3
- Q.2 Which of the following is NOT correct? Nptel Reference 4
 (A) Dislocations are thermodynamically unstable defects.
 (B) Dislocations can move inside a crystal under the action of an applied stress.
 (C) Screw dislocations can change the slip plane without climb Nptel Reference
 (D) Burger's vector of an edge dislocation is parallel to the dislocation line.
- Q.3 At a constant atmospheric pressure, the number of phases, P which coexist in a chosen system at equilibrium, is related to the number of components, C in the system and the degree of freedom, F by Nptel Reference
 (A) $P+F=C-2$ (B) $P+F=C+2$
 (C) $P+F=C+1$ (D) $P+F=C-1$
- Q.4 Which one of the following metals is commonly alloyed with iron to improve its corrosion resistance? Nptel Reference
 (A) Co (B) Cr (C) Ti (D) Nb
- Q.5 The number of slip systems in a metal with FCC crystal structure is Nptel Reference
 (A) 4 (B) 6 (C) 8 (D) 12
- Q.6 Upon recrystallization of a cold worked metal, Nptel Reference
 (A) strength increases and ductility decreases
 (B) strength decreases but ductility increases
 (C) both strength and ductility increase
 (D) both strength and ductility decrease

- Q.7 In carbon fiber reinforced resin composites, for a given fiber volume content, Young's modulus depends on the orientation of the fiber with respect to the applied load. Which orientation of the fibers will give the maximum value of Young's modulus? Nptel Reference
- (A)transverse (B)longitudinal
(C)random (D)both transverse and longitudinal
- Q.8 Vulcanization is related to Nptel Reference 1
- (A)strengthening of rubber (B)extrusion Nptel Reference 2
(C)injection moulding (D)addition polymerisation
- Q.9 Which one of the following oxides crystallizes into fluorite structure? Nptel Reference 1
- (A) UO_2 (B) MgO (C) $BaTiO_3$ (D) $MgAl_2O_4$ Nptel Reference 2

Q. 10 - Q. 22 carry two marks each. Nptel Reference 3

- Q.10 Match the conventional ceramic materials listed in **Column I** with their respective common applications in **Column II** Nptel Reference 1
- | <u>Column I</u> | <u>Column II</u> | |
|----------------------------------|----------------------------|-------------------|
| P. Lead Zirconate Titanate (PZT) | 1. cutting tool | Nptel Reference 2 |
| Q. Zinc Oxide (ZnO) | 2. thermal barrier coating | Nptel Reference 3 |
| R. Silicon Carbide (SiC) | 3. actuator | Nptel Reference 4 |
| S. Zirconia (ZrO_2) | 4. varistor | Nptel Reference 4 |
| | 5. super conductor | |
| (A) P-1, Q-2, R-3, S-5 | (B) P-3, Q-2, R-1, S-5 | |
| (C) P-2, Q-1, R-5, S-3 | (D) P-3, Q-4, R-1, S-2 | |
- Q.11 Match the terminologies given in **Column I** with their relations listed in **Column II** Nptel Reference 1
- | <u>Column I</u> | <u>Column II</u> | |
|-----------------------------|---------------------------------|-------------------|
| P. domain wall | 1. superconductors | Nptel Reference 2 |
| Q. Fick's law | 2. mechanical properties | Nptel Reference 3 |
| R. Matthiessen's rule | 3. ferromagnetic materials | Nptel Reference 4 |
| S. Hall-Petch relation | 4. resistivity of impure metals | Nptel Reference 5 |
| T. Meissner effect | 5. diffusion | Nptel Reference 6 |
| (A) P-1, Q-3, R-5, S-2, T-4 | (B) P-3, Q-5, R-2, S-4, T-1 | |
| (C) P-3, Q-5, R-4, S-2, T-1 | (D) P-3, Q-4, R-3, S-2, T-4 | |
- Q.12 Match the microscopes listed in **Column I** with their principle of operation listed in **Column II**
- | <u>Column I</u> | <u>Column II</u> | |
|---|---|-------------------|
| P. Scanning Electron Microscope (SEM) | 1. van der Waals forces between atoms | |
| Q. Transmission Electron Microscope (TEM) | 2. electrons to jump across a potential barrier | Nptel Reference 1 |
| R. Scanning Tunnelling Microscope (STM) | 3. diffraction of electrons | Nptel Reference 2 |
| S. Atomic Force Microscope (AFM) | 4. detection of secondary electrons | Nptel Reference 3 |
| | 5. photo emission of electrons | Nptel Reference 4 |
| (A) P-2, Q-5, R-3, S-1 | (B) P-3, Q-4, R-5, S-2 | |
| (C) P-4, Q-3, R-2, S-1 | (D) P-4, Q-3, R-5, S-2 | |

- Q.13 X-rays of unknown wavelength are diffracted by an FCC metal with a lattice parameter of 0.352 nm. The measured '2θ' angle for the {200} peak is 61.08°. Calculate the wavelength of the X-ray used, in nm. _____ [Nptel Reference](#)
- Q.14 A metal with HCP crystal structure has lattice constants $a = 0.30$ nm and $c = 0.56$ nm. Determine the volume of the unit cell of this metal, in nm^3 . _____ [Nptel Reference](#)
- Q.15 The band gap of a semiconducting material used to make an LED is 1.43 eV. What will be the minimum wavelength of the radiation emitted by this LED, in μm ? _____ [Nptel Reference 1](#)
[Nptel Reference 2](#)
- Q.16 For automatic control of household electric water heater a relay switch is activated by thermal expansion of a brass rod of length 50 cm as shown in the schematic below. The distance between the rod and the lever, x , is adjusted by moving the base of the rod. As the water gets heated the rod expands and as soon as the rod touches the lever, the circuit is broken disconnecting the heater from the power supply. Find the distance, x , in mm, to be set at water temperature of 20°C such that the circuit is broken at 70°C. The coefficient of linear thermal expansion of brass is $20 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ _____

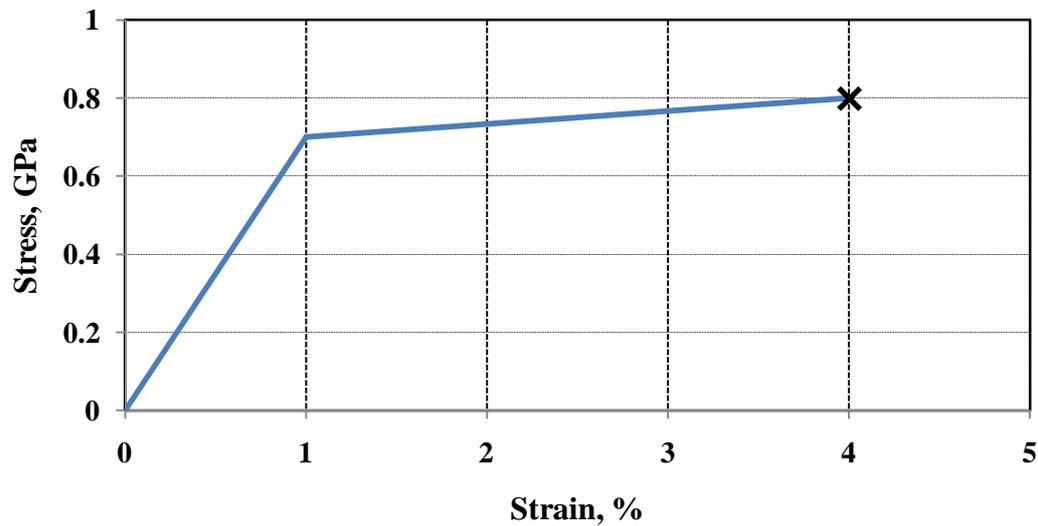
[Nptel Reference 1](#)[Nptel Reference 2](#)

Common Data Questions

Common Data for Questions 17 and 18:

From tensile test of a particular alloy the following values were obtained. The material exhibits linear work hardening as shown in the figure given below.

	At Yield	At Fracture
Stress, GPa	0.7	0.8
Strain, %	1	4



Q.17 If the cylindrical specimen had a dimension of diameter 10 mm and length 50 mm, find the length of the specimen at the yield point, in mm. _____

[Nptel Reference 1](#)

[Nptel Reference 2](#)

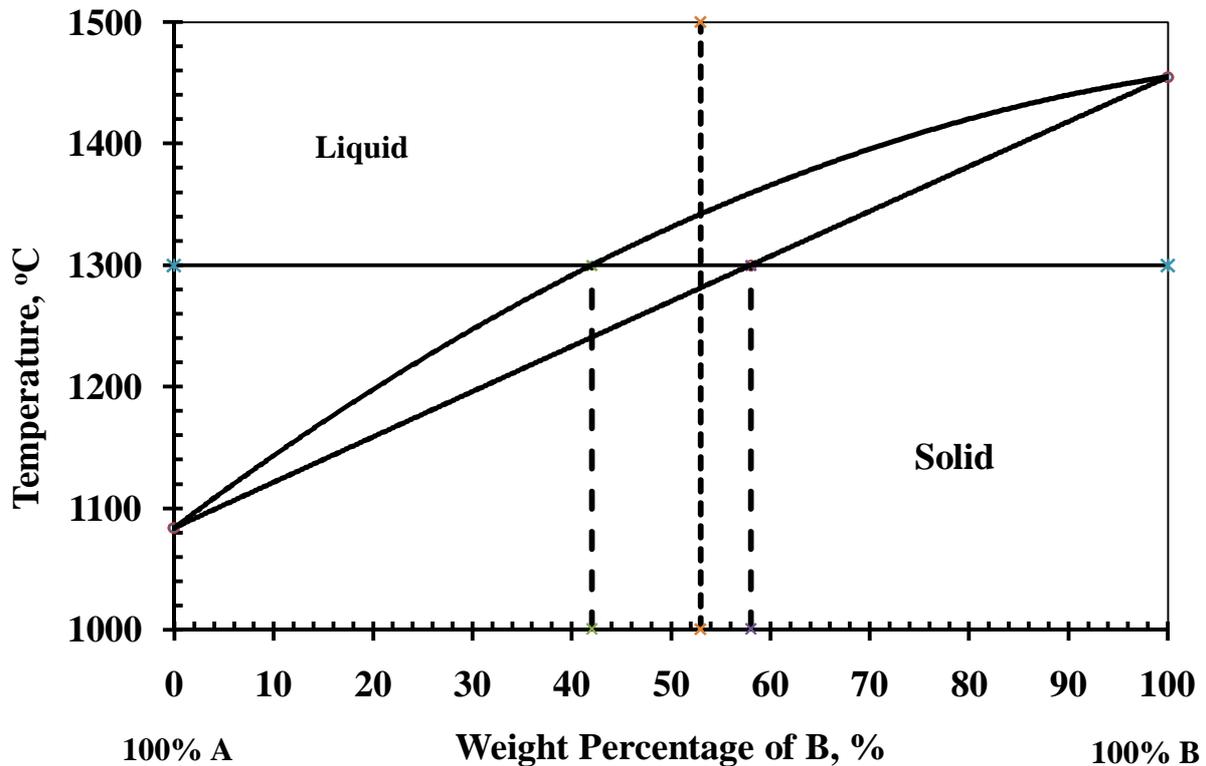
Q.18 Find the toughness of the material, in M J m^{-3} . _____

[Nptel Reference 1](#)

[Nptel Reference 2](#)

Common Data for Questions 19 and 20:

An isomorphous alloy system contains 47 wt% of A and 53 wt % of B and is at 1300° C. Referring to the figure given below, answer the following:



Q.19 What is the weight percentage of A in solid phase at this temperature? _____

[Nptel Reference 1](#)

[Nptel Reference 2](#)

Q.20 What weight percentage of this alloy is liquid? _____

[Nptel Reference 1](#)

[Nptel Reference 2](#)

Linked Answer Questions

Statement for Linked Answer Questions 21 and 22:

A stress of 10 MPa is applied to an elastomer to generate a strain of 50%. The strain is held constant at this value. After 40 days at 20°C, the stress decreases to 5 MPa.

Q.21 What is the relaxation time constant for this material? _____

Q.22 What will be the stress after 60 days at 20°C? _____

END OF SECTION - C