XE (C): Q. 1 – Q. 9 carry one mark each & Q. 10 – Q. 22 carry two marks each.

Q.1 The stress ratio for a completely reversed cyclic loading during a fatigue test is

(A) 0 (B) 1 (C) –1 (D) –1/2

Q.2 Minimum symmetry that a cubic crystal must possess is

(A) four 3-fold rotation axes.
(B) three 4-fold rotation axes.
(C) three orthogonal mirror planes.
(D) centre of symmetry.

Q.3 If a material is repelled in an external magnetic field then it is

(A) Ferromagnetic (B) Diamagnetic
(C) Paramagnetic (D) Antiferromagnetic

Q.4 An electron makes a transition from the valence band to the conduction band in an indirect band gap semiconductor. Which one of the following is true?

(A) Energy of the electron decreases.
(B) A photon is emitted in the process.
(C) A phonon is annihilated in the process.
(D) A photon is created in the process.

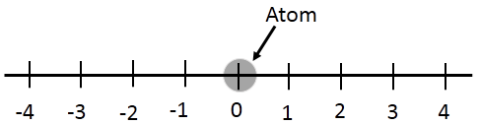
Q.5 Which one of the following is the characteristic of a screw dislocation?

(A) Dislocation line and Burgers vector are parallel.
(B) Direction of motion of dislocation is parallel to the Burgers vector.
(C) Atomic displacement due to the movement of the dislocation is in the direction of the motion of the dislocation line.
(D) It has a unique slip plane.

Q.6 The number of vibrational degrees of freedom for a non-linear triatomic molecule are

(A) 9 (B) 6 (C) 4 (D) 3

Q.7 An atom is restricted to move in one dimension by making unit jumps either to the left or right, as shown in the figure. Assuming that a jump to the left or right is equally probable, the probability of the atom returning back to the starting point after four jumps is



(A) 0.250 (B) 0.333 (C) 0.375 (D) 0.500

Q.8 For a two-dimensional solid, the variation of lattice specific heat as a function of temperature *T* (in K, at low temperatures) is given as: $C_p = bT^n$, where *b* is a constant. The value of *n* is _____.

Q.9 If the cation (C) to anion (A) radius ratio, r_C/r_A is 0.6, then the coordination number (i.e., number of *A* ions surrounding a *C* ion) is likely to be _____.

Q.10 Match the invariant reactions in Column I with the names in Column II (*L* is liquid phase, and α, β, γ are solid phases). All reactions proceed to the right on cooling.

Column I	Column II
(P) $L \rightleftarrows \alpha + \beta$	(1) Monotectic
(Q) $L + \alpha \rightleftarrows \beta$	(2) Peritectoid
(R) $\gamma \rightleftarrows \alpha + \beta$	(3) Peritectic
(S) $\alpha + \beta \rightleftarrows \gamma$	(4) Eutectoid
	(5) Eutectic

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

Q.11 Consider the following anodic (oxidation) reaction in an acidic solution:

$$Mg \longrightarrow Mg^{+2} + 2e^-$$

If 48250 Coulomb charge is produced during this anodic reaction then the amount of Mg (in g) dissolved into the solution is
(Given: Faraday Constant =96500 C/mole of electrons, Atomic weight of Mg = 24)

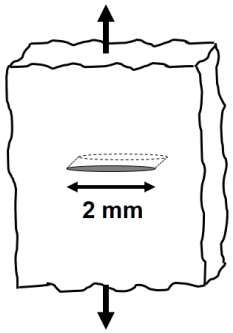
(A) 6 (B) 12 (C) 24 (D) 48

Q.12 An intrinsic semiconductor has conduction electron concentration, $n = 10^{12}$ cm^{-3}. The mobility of both electrons and holes are identical = 4×10^4 cm^2 V^{-1} s^{-1}. If a voltage of 100 V is applied on two parallel end faces of the cube (edge length 1 cm) through Ohmic contacts, the current through the cube would be (in mA)
(Given: charge of electron = 1.6×10^{-19} C)

(A) 640 (B) 1280 (C) 6400 (D) 12800

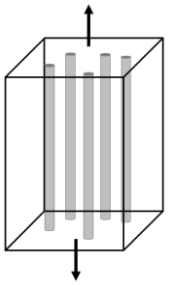
Q.13 An infinite plate with a through-thickness crack of length 2 mm is subjected to a tensile stress (as shown in the figure). Assuming the plate to be linear elastic, the fracture stress is _____ MPa *(round off to the nearest whole number)*

(Given: Fracture toughness, $K_{IC} = 25\ MPa\sqrt{m}$)



Q.14 A unidirectionally aligned carbon fibre reinforced epoxy composite is loaded as shown in the figure. The volume fraction of the fibre is 0.6. The Young's modulus of the composite is _____ GPa.

(Given: Young's Modulus of the fibre and the matrix are 200 GPa and 10 GPa, respectively)



Q.15 A sintered sample was weighed in air and water using an analytical balance. The mass of the sample in air is 2.67 g and its apparent mass in water is 1.67 g. The density of the sample is _____ g cm^{-3} *(give answer up to 2 decimal places)*

(Given: Density of water = 1.00 g cm^{-3})

Q.16 The atoms in a gas laser have two energy levels such that a transition from the higher to the lower level releases a photon of wavelength 500 nm. If 7×10^{20} atoms are pumped into the upper level with 4×10^{20} atoms in the lower level, the amount of energy released in a single pulse is _____ Joules *(give answer up to 2 decimal places)*

(Given: Planck's constant, $h = 6.6 \times 10^{-34}$ J s; speed of light, $c = 3 \times 10^8$ m s^{-1})

Q.17 The speed of an electron is measured to be 300 m s^{-1} with an uncertainty of 0.01%. The fundamental accuracy with which the position of the electron can be determined simultaneously with the speed in the same experiment is _____ mm *(give answer up to 2 decimal places)*

(Given: Planck's constant, $h = 6.6 \times 10^{-34}$ J s; mass of electron = 9.1×10^{-31} kg)

Q.18 When 3 identical non-interacting spin ½ particles are put in an infinite potential well, the ground state energy of the system is 18 meV. If instead, seven particles are put inside the potential well, the new ground state energy is _____ meV.

Q.19 If the value of the integral (I) is 4, the value of the constant b is _____ *(give answer up to 2 decimal places).*

$$I = \int_{-\infty}^{\infty} e^{\frac{-x^2}{b}}\, dx$$

Q.20 X-ray diffraction pattern is obtained from FCC polycrystalline aluminium (lattice parameter = 0.405 nm) using Cr-Kα radiation of wavelength 0.229 nm. The maximum number of peaks that can be observed in the pattern is _____.

Q.21 The planar atomic density in the (110) plane of a BCC iron crystal is _____ nm^{-2} *(give answer up to 2 decimal places)*

(Given: lattice parameter of iron is 0.287 nm)

Q.22 Mild steel is carburized at 1300 K for 1 hour to obtain a certain case depth. Keeping the time as 1 hour, the case depth can be doubled by increasing the temperature to _____K *(round off to the nearest whole number)*

(Given: Activation energy Q = 148 kJ mol^{-1}, Gas constant, R = 8.314 J mol^{-1} K^{-1})

END OF THE QUESTION PAPER

Q.No.	Type	Section	Key/Range	Marks
1	MCQ	GA	A	1
2	MCQ	GA	C	1
3	MCQ	GA	B	1
4	MCQ	GA	B	1
5	MCQ	GA	B	1
6	MCQ	GA	A	2
7	MCQ	GA	D	2
8	MCQ	GA	D	2
9	MCQ	GA	B	2
10	MCQ	GA	C	2
1	MCQ	XE-A	D	1
2	MCQ	XE-A	A	1
3	NAT	XE-A	0.01 to 0.01	1
4	NAT	XE-A	5 to 5	1
5	NAT	XE-A	0.29 to 0.32	1
6	NAT	XE-A	250 to 250	1
7	NAT	XE-A	108 to 108	1
8	MCQ	XE-A	B	2
9	MCQ	XE-A	C	2
10	NAT	XE-A	3 to 3	2
11	NAT	XE-A	0.04 to 0.04	2
1	MCQ	XE-B	B	1
2	MCQ	XE-B	A	1

Q.No.	Type	Section	Key/Range	Marks
3	MCQ	XE-B	D	1
4	MCQ	XE-B	A	1
5	MCQ	XE-B	C	1
6	MCQ	XE-B	B	1
7	MCQ	XE-B	A	1
8	NAT	XE-B	4 to 4	1
9	NAT	XE-B	39 to 42	1
10	MCQ	XE-B	B	2
11	MCQ	XE-B	C	2
12	MCQ	XE-B	C	2
13	MCQ	XE-B	A	2
14	NAT	XE-B	900 to 990	2
15	NAT	XE-B	40 to 42	2
16	NAT	XE-B	2.9 to 3.1	2
17	NAT	XE-B	107 to 127	2
18	NAT	XE-B	440000 to 442000	2
19	NAT	XE-B	0.001 to 0.002	2
20	NAT	XE-B	30 to 45	2
21	NAT	XE-B	4800 to 4800	2
22	NAT	XE-B	1200 to 1350	2
1	MCQ	XE-C	C	1
2	MCQ	XE-C	A	1
3	MCQ	XE-C	B	1

Q.No.	Type	Section	Key/Range	Marks
4	MCQ	XE-C	C	1
5	MCQ	XE-C	A	1
6	MCQ	XE-C	D	1
7	MCQ	XE-C	C	1
8	NAT	XE-C	2 to 2	1
9	NAT	XE-C	6 to 6	1
10	MCQ	XE-C	B	2
11	MCQ	XE-C	A	2
12	MCQ	XE-C	B	2
13	NAT	XE-C	430 to 500	2
14	NAT	XE-C	124 to 124	2
15	NAT	XE-C	2.60 to 2.70	2
16	NAT	XE-C	59.00 to 60.00	2
17	NAT	XE-C	1.85 to 2.00	2
18	NAT	XE-C	132 to 132	2
19	NAT	XE-C	5.01 to 5.17	2
20	NAT	XE-C	5 to 5	2
21	NAT	XE-C	15.5 to 18.5	2
22	NAT	XE-C	1420 to 1480	2
1	MCQ	XE-D	D	1
2	MCQ	XE-D	A	1
3	MCQ	XE-D	D	1
4	MCQ	XE-D	B	1

Q.No.	Type	Section	Key/Range	Marks
5	MCQ	XE-D	B	1
6	NAT	XE-D	52.50 to 53.50	1
7	NAT	XE-D	27.00 to 28.00	1
8	NAT	XE-D	80 to 80	1
9	NAT	XE-D	220.00 to 222.00	1
10	MCQ	XE-D	B	2
11	MCQ	XE-D	B	2
12	MCQ	XE-D	D	2
13	MCQ	XE-D	C	2
14	MCQ	XE-D	C	2
15	MCQ	XE-D	A	2
16	MCQ	XE-D	D	2
17	NAT	XE-D	195.00 to 197.00	2
18	NAT	XE-D	0.01 to 0.02	2
19	NAT	XE-D	14.5 to 15.5	2
20	NAT	XE-D	26.00 to 27.00	2
21	NAT	XE-D	3.10 to 3.20	2
22	NAT	XE-D	13.5 to 14.5	2
1	MCQ	XE-E	B	1
2	MCQ	XE-E	A	1
3	MCQ	XE-E	C	1
4	MCQ	XE-E	A	1
5	MCQ	XE-E	C	1

Q.No.	Type	Section	Key/Range	Marks
6	MCQ	XE-E	D	1
7	NAT	XE-E	160.0 to 161.0	1
8	NAT	XE-E	14.5 to 15.0	1
9	NAT	XE-E	0.30 to 0.32	1
10	MCQ	XE-E	C	2
11	MCQ	XE-E	C	2
12	MCQ	XE-E	D	2
13	MCQ	XE-E	B	2
14	MCQ	XE-E	A	2
15	MCQ	XE-E	D	2
16	NAT	XE-E	332.5 to 336.5	2
17	NAT	XE-E	3.01 to 3.07	2
18	NAT	XE-E	838.0 to 844.0	2
19	NAT	XE-E	961.0 to 962.0	2
20	NAT	XE-E	5.7 to 6.1	2
21	NAT	XE-E	12950.0 to 13000.0	2
22	NAT	XE-E	513.0 to 517.0	2
1	MCQ	XE-F	C	1
2	MCQ	XE-F	A	1
3	MCQ	XE-F	D	1
4	MCQ	XE-F	B	1
5	MCQ	XE-F	D	1
6	MCQ	XE-F	B	1

Q.No.	Type	Section	Key/Range	Marks
7	MCQ	XE-F	A	1
8	NAT	XE-F	1500.00 to 1500.00	1
9	NAT	XE-F	48.52 to 48.72	1
10	MCQ	XE-F	D	2
11	MCQ	XE-F	A	2
12	MCQ	XE-F	B	2
13	MCQ	XE-F	D	2
14	MCQ	XE-F	B	2
15	MCQ	XE-F	D	2
16	MCQ	XE-F	C	2
17	MCQ	XE-F	C	2
18	NAT	XE-F	-25.00 to -24.50	2
19	NAT	XE-F	98.80 to 99.10	2
20	NAT	XE-F	0.90 to 0.93	2
21	NAT	XE-F	17.91 to 18.00	2
22	NAT	XE-F	2600 to 2600	2
1	MCQ	XE-G	B	1
2	MCQ	XE-G	A	1
3	MCQ	XE-G	C	1
4	MCQ	XE-G	D	1
5	MCQ	XE-G	D	1
6	NAT	XE-G	1.55 to 1.65	1
7	NAT	XE-G	103.0 to 103.2	1

Q.No.	Type	Section	Key/Range	Marks
8	NAT	XE-G	54 to 56	1
9	NAT	XE-G	0 to 0	1
10	MCQ	XE-G	B	2
11	MCQ	XE-G	C	2
12	MCQ	XE-G	C	2
13	MCQ	XE-G	A	2
14	MCQ	XE-G	D	2
15	MCQ	XE-G	A	2
16	MCQ	XE-G	C	2
17	MCQ	XE-G	B	2
18	NAT	XE-G	9.8 to 10.2	2
19	NAT	XE-G	1.1 to 1.8	2
20	NAT	XE-G	14.5 to 15.5	2
21	NAT	XE-G	6.0 to 6.4	2
22	NAT	XE-G	10 to 10	2
1	MCQ	XE-H	B	1
2	MCQ	XE-H	C	1
3	MCQ	XE-H	A	1
4	MCQ	XE-H	B	1
5	MCQ	XE-H	B	1
6	MCQ	XE-H	C	1
7	MCQ	XE-H	D	1
8	MCQ	XE-H	D	1

Q.No.	Type	Section	Key/Range	Marks
9	MCQ	XE-H	B	1
10	MCQ	XE-H	A	2
11	MCQ	XE-H	B	2
12	MCQ	XE-H	A	2
13	MCQ	XE-H	B	2
14	NAT	XE-H	1254 to 1256	2
15	NAT	XE-H	19.42 to 19.44	2
16	NAT	XE-H	734.8 to 735.0	2
17	NAT	XE-H	9.16 to 9.18	2
18	NAT	XE-H	12.8 to 13.2	2
19	NAT	XE-H	92.4 to 92.8	2
20	NAT	XE-H	1.3 to 1.4	2
21	NAT	XE-H	0.11 to 0.12	2
22	NAT	XE-H	9.99 to 10.01	2