UPES SAP ID No.: _________________

UNIVERSITY WITH A PURPOSE

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

Examination, July 2020

Programme: B.Sc.(Hons.) Mathematics & Chemistry **Semester : II**
Course Name: Solid State Physics (Generic Elective) **Max. Marks : 100**
Course Code: PHYS 1019 **Attempt Duration: 3 Hrs.**
No. of page/s: 6

Note:

1. Read the instruction carefully before attempting.
2. This question paper has two section, Section A and Section B.
3. There are total of nine questions in this question paper. **One** in **Section A** and **eight** in **Section B**.
4. **Section A** consist of multiple choice based questions and has the total weightage of 60%.
5. **Section A** will be conducted online on BB Collaborate platform
6. **Section B** consist of long answer based questions and has the total weightage of 40%. The questions for section B shall also appear in BB Collaborate
7. **Section B** is to be submitted within 24 hrs from the scheduled time i.e. if the examination starts at 10:00 AM, the long answers must be submitted by 09:59:59 AM next day. Similarly, if the examination starts at 2:00 PM it must be submitted by 01:59:59 PM next day. (*Exceptional provision due extraordinary circumstance due to COVID-19 and due to internet connectivity issues in the far-flung areas*).
8. No submission of **Section B** shall be entertained after 24 Hrs.
9. **Section B** should be attempted after **Section A**
10. **Section B** should be attempted on blank white sheets (hand written) with all the details like programme, semester, course name, course code, name of the student, Sap id at the top (as in the format) and signature at the bottom (right hand side bottom corner)
11. Both section A & B should have questions from the entire syllabus.
12. The COs mapping, internal choices within a section is same as earlier

Section – A (Attempt all the questions)
(60 Marks)

1. MCQs

1. X-rays diffract from solid crystals due to which property of the crystals (a) colour of the crystals (b) periodic array of atoms	**2**	**CO1**

(c) random arrangement of atoms (d) none of these		
2. The nearest neighbour distance in the case of bcc structure is (a) $(a\sqrt{3})/2$ (b) $(a\sqrt{2})/2$ (c) $2a/\sqrt{3}$ (d) $2a/\sqrt{2}$	**2**	**CO1**
3. If (3 2 6) are the Miller indices of a plane, the intercepts made by the plane on the three crystallographic axes are (a) (2a, 3b, c) (b) (a, b, c) (c) (a, 2b, 3c) (d) (3a, 3b, 2c)	**2**	**CO1**
4. In a simple cubic lattice $d_{1\,0\,0} : \ d_{1\,1\,0} : \ d_{1\,1\,1}$ is (a) 6 : 3 : 2 (b) 6 : 3 : $\sqrt{2}$ (c) $\sqrt{6} : \sqrt{3} : \ \sqrt{2}$ (d) $\sqrt{6} : \sqrt{3} : \ \sqrt{4}$	**3**	**CO1**
5. If the applied potential in a X-ray tube is 50 kV, then maximum wavelength of the produced X-rays is (a) 0.2 nm (b) 2 nm (c) 0.2 Å (d) 2 Å	**3**	**CO1**
6. The density of vibrational modes in a continuous elastic medium is (a) $4\pi\vartheta d\vartheta\left[\frac{2}{v_t^3}+\frac{1}{v_l^3}\right]$ (b) $4\pi\vartheta^2 d\vartheta\left[\frac{2}{v_l^3}+\frac{1}{v_t^3}\right]$ (c) $4\pi\vartheta^2 d\vartheta\left[\frac{2}{v_t^3}+\frac{1}{v_l^3}\right]$ (d) none of these	**2**	**CO1**
7. If the Debye's temperature of a metal is 450 K, the Debye's frequency is (a) 10 Hz (b) 10^2 Hz (c) 10^{13} Hz (d) 10^{23} Hz	**2**	**CO1**
8. Phonons can be defined as	**2**	**CO1**

(a) quantized normal modes of electromagnetic waves (b) quantized normal modes of electric polarization in solids (c) quantized normal modes of molecular rotational excitations (d) quantized normal modes of lattice vibrations		
9. If the Debye temperature of diamond is 2000 K with an interatomic spacing 1.54 Å then the magnitude of the dominant phonon wavelength at a temperature of 298 K is (a) $1.03 \times 10^{-23}\ m$ (b) $1.03 \times 10^{-13}\ m$ (c) $1.03 \times 10^{-11}\ m$ (d) $1.03 \times 10^{-9}\ m$	**3**	**CO1**
10. Curie-Weiss law is (a) $\chi_m = C/T$ (b) $\chi_m = C/(T-\theta)$ (c) $\chi_m = (T-\theta)/C$ (d) $\chi_m = C/\theta - T$	**2**	**CO2**
11. The susceptibility of a diamagnetic material is independent of temperature (a) under all circumstances (b) as long as the electronic structure is independent of temperature (c) at very low temperatures of the order of 10 K (d) at very high temperatures	**2**	**CO2**
12. Diamagnetic susceptibility of a solid material with $N = 5 \times 10^{28}/m^3$ and $r = 0.1\ nm$ is (where N is numer of atoms per unit volume of the solid and r is the mean distance of electrons relative to the nucleus) (a) $-3 \times 10^{-3}\ cm^{-3}$ (b) $-6 \times 10^{-3}\ cm^{-3}$ (c) $-3 \times 10^{-6}\ cm^{-3}$ (d) $-6 \times 10^{-6}\ cm^{-3}$	**3**	**CO2**
13. The hysteresis loss is (a) directly proportional to the area under the hysteresis loop (b) inversely proportional to the area under the hysteresis loop (c) directly proportional to square of the area under the hysteresis loop (d) none of these	**2**	**CO2**
14. The relative permittivity of argon at 0 ^{o}C and at 1 atmospheric pressure is 1.000435. Then the polarizability of the atom if the gas contains $2.7 \times 10^{25}\ atoms\ m^{-3}$ is ($\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$) (a) $1.426 \times 10^{-10}\ F\ m^2$ (b) $1.426 \times 10^{-20}\ F\ m^2$ (c) $1.426 \times 10^{-30}\ F\ m^2$	**3**	**CO3**

(d) $1.426 \times 10^{-40}\ F\ m^2$		
15. The dielectric strength of porcelain is $6\times 10^6\ V/m$. What should be the thickness of a porcelain sheet when it is subjected to a breakdown voltage of the order of $10^6\ V$? (a) 0.167 cm (b) 16.7 cm (c) 9.2 cm (d) 11.3 cm	**3**	**CO3**
16. The number of polarization mechanisms involved in a dielectric are (a) 1 (b) 2 (c) 4 (d) 6	**2**	**CO3**
17. In between two absorption bands, the index always increases toward shorter wavelengths, this is known as (a) normal dispersion (b) anomalous dispersion (c) resonant dispersion (d) none of these	**2**	**CO3**
18. Electromagnetic radiation has photons and mechanical vibration has phonons. Similarly, plasma oscillation has plasmons. A plasmon is a (a) quasi-particle defined as a quantum of plasma oscillation (b) semi-quasi-particle defined as a quantum of plasma oscillation (c) non-quasi-particle (d) none of these	**2**	**CO3**
19. If an energy level 0.25 eV above the Fermi energy is occupied by an electron at 300 K then what would be its probability of occupying that energy level. (a) 0% (b) 0.6% (c) 0.006% (d) 0.0006%	**3**	**CO4**
20. If an electric field of 100 V/m is applied to a sample of N-type semiconductor whose Hall coefficient is 0.0125 m^3/C then the current density in the sample would be (given, $\mu_n = 0.36\ m^2V^{-1}s^{-1}$) (a) $2000\ A/m^2$ (b) $1500\ A/m^2$ (c) $2280\ A/m^2$ (d) $2880\ A/m^2$	**3**	**CO4**

21. The intrinsic carrier concentration (n_i) at 300 K in silicon is $1.5 \times 10^{16}/m^3$ and the mobilities of electrons and holes in silicon are 0.13 m^2/Vs and 0.05 m^2/Vs, respectively then the conductivity of intrinsic silicon at 300 K would be (a) $4.32 \times 10^{-4}\ \Omega m$ (b) $2.32 \times 10^{-4}\ \Omega m$ (c) $3.32 \times 10^{-4}\ \Omega m$ (d) $1.32 \times 10^{-4}\ \Omega m$	**3**	**CO4**
22. The mobility of charge carriers in semiconductors is proportional to (a) 1/T (b) $1/T^{3/2}$ (c) $T^{3/2}$ (d) T^2	**2**	**CO4**
23. The London penetration depth is given by (a) $\lambda = \sqrt{n_s/m\mu_0 e^2}$ (b) $\lambda = \sqrt{m/n_s\mu_0 e^2}$ (c) $\lambda = \sqrt{n_s m\mu_0 e^2}$ (d) none of these	**2**	**CO4**
24. The transition temperature of most of the superconducting elements lie in the range (a) 0 to 10 K (b) 10 K to 20 K (c) 20 K to 50 K (d) above 50 K	**2**	**CO4**
25. Lead in a superconducting state has critical temperature of 6.2 K at zero magnetic field and a critical field of 0.064 M A/m at 0 K then the critical field at 4 K would be (a) 37 M A/m (b) 0.037 M A/m (c) 0.37 M A/m (d) none of these	**3**	**CO4**

****

Section – B (Attempt all the questions)
(40 marks)

Q2	The primitive translation vectors of a two-dimensional lattice are $\vec{a} = 2\hat{\imath} + \hat{\jmath}, \qquad \vec{b} = 2\hat{\jmath}$	**5**	**CO1**

	Determine the primitive translation vectors of its reciprocal lattice.		
Q3	An X-ray beam of wavelength 0.71 Å is diffracted by a cubic crystal KCl crystal of density 1.99×10^{3} kgm^{-3}. Calculate the interplanar spacing for the (200) planes and the glancing angle for the second order reflection from these planes. The molecular weight of KCl is 74.6 amu and the Avogadro's number is 6.023×10^{26} $kg^{-1}mol^{-1}$.	**5**	**CO1**
Q4	Derive the expression of Debye theory of specific heat of solids for low temperature case and show that the vibrational energy is analogous to the Stephen's law of black body radiation.	**5**	**CO1**
Q5	Describe briefly the classical Langevin theory of diamagnetic domains.	**5**	**CO2**
Q6	The dielectric constant of helium having $2.7 \times 10^{25}/m^{3}$, measured at 0 ºC and at one atmosphere is, 1.0000684. Calculate the atomic radius of helium.	**5**	**CO3**
Q7	Using the Kronig-Penney model, show that for $P \ll 1$, the energy of the lowest energy band is $$E = \frac{\hbar^2 P}{ma^2}$$	**5**	**CO4**
Q8	Explain the difference between Type I and Type II superconductors. The transition temperature of mercury with an average atomic mass of 200.59 amu is 4.153 K. Determine the transition temperature of one of its isotopes, $_{80}Hg^{204}$.	**5**	**CO4**
Q9	For ice, relaxation time is given as 18×10^{-6} s at 22 ºC. Calculate the frequency when the real and imaginary parts of the complex dielectric constant will become equal. What will be the phase difference between the current and voltage at this frequency?	**5**	**CO3**

****