C 20225 **(Pages : 3)** **Name.....**

Reg. No.....

SIXTH SEMESTER (CUCBCSS—UG) DEGREE EXAMINATION, MARCH 2022

Physics/Applied Physics

PHY 6B 11/APY 6B 12—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

(2014 to 2018 Admissions)

Time : Three Hours Maximum : 80 Marks

Section A

Answer in word **or** *a phrase each.*
Answer **all** *questions.*
Each question carries 1 *marks.*

1. The process of determination of crystal structure is called ————.
2. X-rays are produced when an element of high atomic weight is bombarded by high energy ————.
3. The vibrational energy of lowest energy state is called ————.
4. In Raman scattering, if the scattered photon have energy $h(v_0 + v_m)$ that corresponds to ———— line.
5. If the number of atoms in the excited state is greater than that in the lower energy level, it is called

Questions 6 to 10 : Write True *or* False :

6. Crystalline solids are anisotropic.
7. In an asymmetric top molecule, all the three moment of inertia are distinct.
8. Soft superconductors show Meissner effect.
9. X-rays have electromagnetic wave nature as ordinary light.
10. In superconductors, the critical field depends on temperature.

(10 × 1 = 10 marks)

Section B

Answer in two **or** *three sentences each.*
Answer **all** *questions.*
Each question carries 2 *marks.*

11. Define crystal lattice.
12. What is Meissner effect ?

Turn over

13. What is Doppler broadening ?

14. Write down Bragg's equation.

15. Why anti-stokes lines are less intense than stokes lines ?

16. Distinguish between stimulated emission and spontaneous emission.

17. Write any 4 medical applications of laser.

(7 × 2 = 14 marks)

Section C

Answer in a paragraph of about **half a page to one page** *each.*
Answer any **five** *questions.*
Each question carries 4 *marks.*

18. Write a brief note on crystal systems.

19. Distinguish between Type I and Type II superconductors.

20. Write a note on Absorption instruments.

21. Outline the effect of isotopic substitution on the rotational spectra of molecules.

22. Write a note on vibrational Raman spectra.

23. Which are the factors that affect the intensity of spectral lines ?

24. What are Einstein's co-efficients ?

(5 × 4 = 20 marks)

Section D

Problems : write all relevant formulas, all important steps carry separate marks.
Answer any **four** *questions.*
Each question carries 4 *marks.*

25. A Raman line is observed at 4768.5A° when acetylene was radiated by 4358.3A° radiations. Calculate the vibrational frequency that causes this shift.

26. An atom has two atomic levels spaced by 3eV in energy. Calculate the ratio of population in higher and lower energy at 50°C. Boltzmann's constant = 1.38×10^{-23}J/K.

27. What is the minimum voltage applied to an X-ray tube to produce X-rays of 0.5A° .

28. Electrons are accelerated to 728 volts and are reflected from a crystal. The first reflection maximum occurs when glancing angle is 8°. Determine the interplanar spacing of the crystal.

29. Copper has fee structure with the lattice constant 0.361nm.Calculate the interplanar spacing for (112) and (120) planes.

30. If the bond length of H_2 is 0.07417nm, what would be the positions of the first three rotational Raman lines in the spectrum? What is the effect of nuclear spin on the spectrum ? $^1H = 1.673 \times 10^{-27}$ kg.

31. The frequency of OH stretching vibration in CH_3OH is 3300cm^{-1}. Estimate the frequency of OD stretching vibration in CH_3OD.

(4 × 4 = 16 marks)

Section E

Essays - answer in about **two pages** *each.*
Answer any **two** *questions.*
Each question carries 10 *marks.*

32. Explain the close-packed structures in crystal.

33. Explain the rotational spectra of rigid diatomic molecule with energy level diagram.

34. Explain the working of Infrared spectrophotometer.

35. Describe a semiconductor laser and explain its working.

(2 × 10 = 20 marks)

C 1265 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER (CUCBCSS—UG) DEGREE EXAMINATION MARCH 2021

Physics/Applied Physics

PHY 6B 11/APY 6B 12—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours Maximum : 80 Marks

Section A

Answer **all** *questions.*
Each question carries 1 *mark.*

Answer in word *or* a phrase :

1. The two dimensional lattice with highest rotational symmetry is ————————.
2. In Raman scattering, if the scattered photon have energy $h(v_0 - v_m)$ that corresponds to ———————— line.
3. In electromagnetic spectrum, the region corresponding to the wavelength 100μm–1μm ————————.
4. The volume of a primitive unit cell of a fcc structure with lattice constant "a" is ————————.
5. A hot band will increase in intensity as temperature of the sample ————————.

Write True *or* False :

6. Amorphous solids are isotropic.
7. In superconductivity critical field depends on temperature.
8. In a symmetric top two of the principal moment of inertia is equal and all the three are non-zero.
9. Unit cell is the building block of a crystal lattice.
10. Molecular absorption takes place at a single frequency.

(10 × 1 = 10 marks)

Turn over

Section B

Answer at least **six** *questions.*
Each question carries 2 *marks.*
All questions can be attended.
Overall Ceiling 12.

11. What is pumping ? Name two different methods of pumping.
12. What is superconductivity ?
13. Vibrational spectra are observable only in the case of heteronuclear diatomic molecule. Why ?
14. What is Type II superconductor ?
15. Explain Raman effect.
16. What is Doppler broadening ?
17. What are hot bands ? Why are they called so ?

(6 × 2 = 12 marks)

Section C

Answer at least **four** *questions.*
Each question carries 5 *marks.*
All questions can be attended.
Overall Ceiling 20.

18. Make drawing of the unit cells and the primitive unit cells for the rutile(TiO_2) and cuprite(Cu_2O) structure.
19. Write a note on BCS theory.
20. Name the different regions of electromagnetic spectra in the order of their increasing frequency.
21. Write a note on the vibrational Raman spectra.
22. Draw the block diagram of a laser system and explain the components .
23. Explain the effect of anharmonicity on the vibrational spectra of diatomic molecule.
24. Explain rotational Raman spectra of symmetric top molecule.

(4 × 5 = 20 marks)

Section D

Answer at least **three** *questions.*
Each question carries 6 *marks.*
All questions can be attended.
Overall Ceiling 18.

25. Find the relative population of the two states in a ruby laser that produces a beam of wavelength 6943A° at 300 K. Boltzmann's constant = 1.38×10^{-23}J/K.

26. Electrons are accelerated to 728 Volts and are reflected from a crystal. The first reflection maximum occurs when glancing angle is 8°. Determine the interplanar spacing of the crystal.

27. Irradiation of carbon tetra chloride by 4358A° radiation gives Raman lines at 4400, 4419 and 4447A°. Calculate the Raman shift for each of these lines.

28. Find the radius of the interstitial sphere that can just fit into the void at the body centre of the fcc structure co-ordinated by the facial atoms.

29. The frequency of OH stretching vibration in CH_3OH is 3300 cm^{-1}. Estimate the frequency of OD stretching vibration in CH_3OD.

30. The first rotational line of ^{12}C ^{16}O is observed at 3.84235 cm^{-1} and that of ^{13}C ^{16}O at 3.67337 cm^{-1}. Calculate the atomic weight of ^{13}C , assuming the mass of ^{16}O to be 15.9949.

31. An atom has two atomic levels spaced by 3eV in energy. Calculate the ratio of population in higher energy and lower energy at 50°C. Boltzmann's constant = 1.38×10^{-23}J/K.

(3 × 6 = 18 marks)

Section E (Essays)

Answer any **two** *questions.*
Each question carries 10 *marks.*

32. Write notes on crystal structures of sodium chloride, diamond and zinc sulphide.

33. State and explain Bragg's law. Explain the working of Bragg's spectrometer.

34. Explain the information derived from rotational spectra about molecular structure.

35. Explain the working of He-Ne laser.

(2 × 10 = 20 marks)

C 80282 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.A./B.Sc. DEGREE EXAMINATION, MARCH 2020

(CUCBCSS—UG)

Physics/Applied Physics

PHY 6B 11/APY 6B 12—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours Maximum : 80 Marks

Section A

Answer in a word **or** *phrase.*

Answer **all** *questions ; each question carries* 1 *mark.*

1. Expand SQUID.
2. Atomic packing factor of a diamond cubic structure is ————.
3. Give an example for simple cubic structure.
4. Which theory explains the superconductivity ?
5. Transition temperature of mercury is ————.
6. The temperature at which the band gap disappears in the case of superconductor is ————.
7. For a non rigid rotator the spacing between the successive spectral lines decreases, true or false
8. Population inversion is a phenomenon in ————.
9. Laser light is highly monochromatic, true or false
10. A superconductor exhibits complete Meissner effect is called ————.

(10 × 1 = 10 marks)

Section B

Answer in a short paragraph-three **or** *four sentences.*

Answer **all** *questions ; each question* carries *2 marks.*

11. What is two fluid model ?
12. State Silsbee's Rule.
13. What is cooper pair ?

Turn over

14. What is mean by coherence length ?

15. Differentiate spontaneous and stimulated emission

16. Define critical magnetic field.

17. What is zero point energy ?

(7 × 2 = 14 marks)

Section C

Answer in **a paragraph** *of about* **half a page to one page.**
Answer any **five** *questions ; each question carries 4 marks.*

18. Explain how X- rays are used for determining the crystal structure.

19. Define the terms : lattice, basis, crystal structure and unit cell.

20. Show that the packing factor of bcc lattice is $\pi\sqrt{3}/8$.

21. Discuss medical applications of laser ?

22. Give the salient features of BCS theory of superconductors.

23. Explain Raman effect.

24. What are Einstein's co-efficients ?

(5 × 4 = 20 marks)

Section D

(Problems - write all relevant formulas. All important steps carry separate marks)
Answer any **four** *questions ; each question carries 4 marks.*

25. In the microwave spectrum of identical rigid diatomic molecules, the separation between the spectral lines is recorded to be 0.7143 cm^{-1}. Find the moment of inertia of the molecule.

26. Calculate the inter planar spacing for (321) plane in simple cubic lattice with inter atomic spacing $a = 4.21\ A^0$.

27. Calculate the critical current which can flow through a long thin superconducting wire of A1 of diameter 10^{-3} m. The critical magnetic field for A1 is $7.9 \times 10^3 A/m$.

28. Derive the expression for volume of unit cell in body centred cubic structure.

29. Derive London's equations and explain how it solution explains Meissner effect.

30. The critical temperature, Tc for mercury with isotopic mass 199.5 is 4.185 K. Calculate its critical temperature when its isotopic mass changes to 203.4.

31. Calculate the angle of incidence at which electrons of energy 100 eV must be incident on the lattice planes of a metal crystal in order to give a strong Bragg reflection in the first order, given that the lattice spacing is 0.252 nm.

(4 × 4 = 16 marks)

Section E

Essays - Answer in about **two pages.**

Answer any **two** *questions ; each question carries* 10 *marks.*

32. Explain Bragg's law and Bragg's X-ray spectrometer.

33. Explain the theory and working of semiconductor laser.

34. Explain the crystal system in detail with examples.

35. Describe an experimental arrangement to study Raman effect. How is Raman scattering different from Compton scattering ?

(2 × 10 = 20 marks)

C 60056 (Pages : 3)

Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH 2019

(CUCBCSS)

Physics

PHY 6B 11/APY 6B 12—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours Maximum : 80 Marks

Section A

Answer in word **or** *phrase.*
Answer **all** *questions.*
Each question carries 1 *mark.*

1. The number of molecules present in the unit cell of sodium chloride is ————.
2. Raman spectrum appears due to the scattering of radiation by the ———— molecules.
3. The miller indices of the plane parallel to Y and Z axes are ————.
4. Soft superconductors observe ———— effect
5. Expand SQUID.
6. The expression for London penetration depth is ————.
7. The lines on the low frequency side of Raman spectra are called ————.
8. The expression for rotational constant B is ————.
9. Give an example for linear molecule.
10. Give an example for high temperature superconductor.

(10 × 1 = 10 marks)

Section B

Answer in a short paragraph-three **or** *four sentences.*
Answer **all** *questions.*
Each question carries 2 *marks.*

11. What is co-ordination number ?
12. State vector form of Bragg's Law.
13. Sketch the magnetic phase diagram of a type II superconductor.

Turn over

14. Distinguish between symmetric top and sperical top molecules.
15. What are hot bands ?
16. Discuss population inversion associated with LASER.
17. Sketch the unit cell of a NaCl crystal.

(7 × 2 = 14 marks)

Section C

Answer in **a paragraph** *of about half a page to one page.*
Answer any **five** *questions.*
Each question carries 4 *marks.*

18. Discuss the applications of LASER.
19. Discuss breakdown of Born Oppenheimer approximation.
20. Compare Raman spectroscopy and Infrared spectrscopy.
21. Give an idea about optical pumping in Lasers.
22. Explain isotopic effect with suitable examples.
23. Explain interaction of radiation with rotating molecules.
24. Discuss vibrational energy of an anharmonic oscillator.

(5 × 4 = 20 marks)

Section D

Problems - write all relevant formulas.
All important steps carry separate marks.
Answer any **four** *questions.*
Each question carries 6 *marks.*

25. The lattice parameter and the atomic mass of a diamond crystal are 3.57 A^0 and 12 respectively. Calculate the density of the same.
26. Show that the packing factor of fcc lattice is $\pi\sqrt{2/6}$.
27. What does the equation dB/dt = 0 tell us ? Is this equation adequate to explain superconductivity? If not, why ?
28. What is the frequency of the electromagnetic waves radiated by a Josephson junction having a voltage of 650 μV across its terminals ?
29. The London penetration depths for Pb at 3K and 7.IK are respectively 39.6 nm and 173 nm. Calculate its transition temperature as well as penetration depth at OK.

30. Consider a He-Ne Laser with cavity life time tc = 5×10^{-8} s. If $R_1 = 1.0$ and $R_2 = 0.98$, Calculate the cavity length d ; assume $n_0 = 1$.

31. In a material at 300K two energy levels have a wavelength separation of 1 μm. Determine

    (a) The ratio of upper to lower level occupation densities when the material is in thermal equilibrium.

    (b) The effective temperature when the levels are equally populated.

(4 × 4 = 16 marks)

Section E (Essays)

Answer in about **two pages.**
Answer any **two** *questions.*
Each question carries 10 *marks.*

32. Explain the spectrum of non- rigid Rotator in detail.

33. Explain the theory and working of Ruby Laser with suitable diagram.

34. Discuss Bragg's Law in detail. Discuss Bragg's X ray spectrometer.

35. Explain rotational Raman spectrum of symmetric top molecule with example.

(2 × 10 = 20 marks)

D 40050

(Pages : 3)

Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH/APRIL 2018

(CUCBCSS—UG)

Physics/Applied Physics

PHY 6B 11/APY 6B 12—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours

Maximum : 80 Marks

Section A (Answer in a Word or a Phrase)

Answer **all** *questions.*
Each question carries 1 *mark.*

1. The number of lattice points in a primitive cell is ———.
2. Name the theory which explains the phenomenon of superconductivity.
3. Give the relation between atomic radius and lattice constant in fcc structure.
4. Expand LASER.
5. The transition temperature of mercury is ———.

Questions 6 *to* 10 *: write True* **or** *False*

6. For a spherical top molecule, all the three principal moment of inertia are equal.
7. The intensities of antistoke lines are greater than stokes lines.
8. The population inversion in Ruby laser is achieved by electrical pumping
9. The vibrational energy at the lowest vibrational level is zero
10. Super conductors are diamagnetic.

(10 × 1 = 10 marks)

Section B (Answer in two or three sentences)

Answer **all** *questions.*
Each question carries 2 *marks.*

11. What are Miller indices ?
12. What is meant by population inversion ?
13. How cooper pairs are formed in superconductors ?
14. What is co-ordination number ?
15. Give the advantage of using laser as a Raman source.

Turn over

16. What are hot bands in vibrating diatomic molecule ?
17. State mutual exclusion principle.

(7 × 2 = 14 marks)

Section C

Answer in a paragraph of about half a page to **one page.**
Answer any **five** *questions.*
Each question carries 4 marks.

18. Discuss the crystal structure of diamond.
19. Derive Bragg's law for X ray diffraction in crystals.
20. Discuss type I and type II superconductors.
21. Discuss normal vibrations of CO_2 and H_2O molecule.
22. Obtain Einstein's coefficients related to emission and absorption.
23. Discuss electromagnetic spectrum.
24. Briefly explain the working of semiconductor laser.

(5 × 4 = 20 marks)

Section D

Problems-write **all** *relevant formulas, all important steps carry separate marks.*
Answer any **four** *questions; each question carries 4 marks*

25. The Raman line associated with a vibrational mode which is both Raman and infrared active is found at 4600 Å when excited by a light of wavelength 4358 Å. Calculate the wavelength of the corresponding infrared band.
26. The critical temperature, T_c for mercury with isotopic mass 199.5 is 4.185 K. Calculate its critical temperature when its isotopic mass changes to 230.4.
27. The first three rotational Raman lines of a linear triatomic molecule are at 4.86, 8.14 and 11.36 cm^{-1} from the exciting Raman line. Estimate the rotational constant B and the moment of inertia of the molecule.
28. The lattice parameter and the atomic weight of a diamond crystal are 3.57 Å and 12 a.m.u. respectively. Calculate the density of the same. Given $N = 6.023 \times 10^{23}$ /mol.
29. A monochromatic X ray beam of $\lambda = 0.7$ Å undergoes first order Bragg reflection from the plane (3 0 2) of a cubic crystal at a glancing angle of 35°. Calculate the lattice constant.

30. Copper has fcc structure of atomic radius 0.1278 nm. Calculate the interplanar spacing for (3 2 1) plane.

31. A He-Ne laser is emitting a laser beam with an average power of 4.5 mW. Find the number of photons emitted per second by the laser. The wavelength of emitted radiation is 6328 Å

(4 × 4 = 16 marks)

Section E (Essays-answer in about two pages)

Answer any **two** *questions.*
Each question carries 10 *marks.*

32. Discuss Bravais lattice and crystal systems with the help of illustrations.

33. Explain with a schematic diagram the working of a He-Ne laser.

34. Explain diatomic vibrating rotator. Discuss the spectrum and relevant selection rules.

35. Discuss rotational Raman spectra of symmetric top molecule. Give example

(2 × 10 = 20 marks)

C 2079

(Pages : 3)

Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH 2017

(CUCBCSS—UG)

Physics/Applied Physics

PHY 6B 11/APY 6B 12—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours

Maximum : 80 Marks

Section A

(Answer in word **or** *a phrase each.)*

Answer **all** *questions ; each question carries* 1 *mark.*

1. The Miller indices of the plane parallel to x and y axes are ————.
2. The co-ordination number in the case of simple cubic crystal structure is ————.
3. The transition temperature of mercury is ————.
4. Expand LASER.
5. The general pumping mechanism in semiconductor laser is ————.

Questions 6 *to* 10 *: write True* **or** *False*

6. For a linear molecule, all the three principal moment of inertia are equal.
7. The symmetric stretching vibration in CO_2 molecule is IR active.
8. The intensities of Stokes lines are greater than anti-Stokes lines.
9. Laser light is highly monochromatic.
10. Soft superconductors show Meissner effect.

(10 × 1 = 10 marks)

Section B

(Answer in two **or** *three sentences each.)*

Answer **all** *questions ; each question carries* 2 *marks.*

11. What are Miller indices ?
12. What is Meissner effect ?
13. Distinguish between symmetric top and spherical top molecules.

Turn over

14. What are hot bands in vibrating diatomic molecule ?

15. What is Raman effect ?

16. What are Einstein's coefficients ?

17. Mention two industrial applications of laser.

(7 × 2 = 14 marks)

Section C

(Answer in a paragraph of about **half a page** *to* **one page** *each.)*
Answer any **five** *questions; each question carries* 4 *marks.*

18. Discuss sodium chloride crystal structure.

19. Discuss type I and type II superconductors.

20. Discuss various regions of electromagnetic spectrum.

21. Discuss rotational spectrum of rigid diatomic molecule.

22. Discuss vibrating diatomic molecule by considering the system as anharmonic.

23. Discuss rotational Raman spectra for linear molecules.

24. Discuss population inversion and metastable state associated with LASER.

(5 ×4 = 20 marks)

Section D

(Problems : write all relevant formulas, all important steps carry separate marks)
Answer any **four** *questions ; each question carries* 4 *marks.*

25. Find the interplanar spacing for the lattice planes of Miller indices (3, 2, 1), (2, 1, 0) and (1, 1, 1) for a cubic lattice with a = 5.62 Å.

26. The interplanar spacing of (110) planes is 2Å for a cubic crystal with fcc structure. Find out the atomic radius.

27. The lattice parameter and the atomic weight of a diamond crystal are 3.57Å and 12 amu respectively. Calculate the density of the same. Given $N_A = 6.023 \times 10^{23}$ /mol.

28. The first line in the rotation spectrum of carbonmonoxide has a frequency of 3.8424 cm^{-1}. Calculate the rotational constant and hence the C—O bond length in carbon monoxide. Avogadro number is 6.023×10^{23} /mol.

29. The normal modes of vibration of CO_2 molecule are $\bar{\nu}_1 = 1330\ cm^{-1}$, $\bar{\nu}_2 = 667\ cm^{-1}$, $\bar{\nu}_3 = 2349\ cm^{-1}$. Evaluate the zero point energy of CO_2 molecule.

30. The Raman line associated with a vibrational mode which is both Raman and infrared active is found at 4600 Å when excited by a light of wavelength 4358Å. Calculate the wavelength of the corresponding infrared band.

31. A He-Ne laser is emitting a laser beam with an average power of 4.5 mW. Find the number of photons emitted per second by the laser. The wavelength of emitted radiation is 6328Å.

(4 × 4 = 16 marks)

Section E

(Essays-answer in about **two pages** *each.)*

Answer any **two** *questions ; each question carries* 10 *marks.*

32. Derive Bragg's law for X-ray diffraction in crystals. How is it verified ? Describe and explain X-ray spectrometer method of determining λ of X-rays.

33. Explain diatomic vibrating rotator. Discuss the spectrum and relevant selection rules.

34. Explain rotational fine structure of vibrational Raman spectrum. State mutual exclusion principle.

35. Explain with a schematic diagram the working of a He-Ne laser.

(2 × 10 = 20 marks)

C 21574 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE (SUPPLEMENTARY/IMPROVEMENT) EXAMINATION, MARCH 2017

(UG–CCSS)

Physics

PH 6B 17—SOLID-STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

(2013 Admissions)

Time : Three Hours Maximum : 30 Weightage

Section A

Answer **all** *questions.*
Objective Type Questions, in bunches of four questions.
Each carries a weightage of 1.

I. 1 The number of lattice points in a primitive cell are :

(a) 1. (b) 2.

(c) 1/2. (d) 3/2.

2 The packing factor of diamond cubic crystal structure is :

(a) 60 %. (b) 56 %.

(c) 90 %. (d) None of these.

3 The Miller indices of the plane parallel to x and y axes are :

(a) (100). (b) (010).

(c) (001). (d) (111).

4 The co-ordination number in the case of simple cubic crystal structure is :

(a) 12. (b) 6.

(c) 1. (d) 2.

II. 5 A proton and an (α particle has the same kinetic energy. If the mass of the (α particle is four times that of proton, how do their de Broglie wavelength compare :

(a) $\lambda_p = \lambda_\alpha / 2$. (b) $\lambda_p = \lambda_\alpha / 4$.

(c) $\lambda_p = 2\lambda_\alpha$. (d) $\lambda_p = 4\lambda_\alpha$.

6 The transition temperature of mercury is :

(a) 1K. (b) 1.14 K.

(c) 4.12 K. (d) 9.22 K.

7 When all the three principal moments of inertia of a molecule are equal, it is called a :

(a) linear molecule. (b) symmetric tops.

(c) spherical tops. (d) asymmetric tops.

8 Transitions between rotational levels within the same vibrational level give spectrum in the :

(a) Visible region. (b) Ultraviolet region.

(c) Infrared region. (d) Far infrared region.

III. 9 Laser light is :

(a) Coherent. (b) Non coherent.

(c) Divergent. (d) Uncoordinated source.

10 The intensities of the anti stoke lines are much :

(a) weaker than the stokes lines. (b) much greater than the stokes lines.

(c) same as stokes lines. (d) None of these.

11 The population inversion in Ruby laser is achieved by :

(a) Electrical discharge. (b) Optical pumping.

(c) Inelastic atomic collision. (d) Direct conversion.

12 Raman scattering is :

(a) Circularly polarized. (b) Elliptically polarized.

(c) Plane polarized. (d) Unpolarised.

(12 × ¼ = 3 weightage)

Section B

Answer **all** *questions.*
Each question carries 1 *weightage.*

13 What are Einstein's coefficients ?

14 What are Miller indices ?

15 What is meant by atomic packing factor ?

16 What are hot bands ?

17 Why anti-stokes lines are less intense than Stokes lines ?

18 What is meant by population inversion ?

19 Outline the effect of isotopic substitution on the rotational spectra of molecules.

20 How cooper pairs are formed in superconductors ?

21 State Bragg's law for X-ray diffraction in crystals.

(9 × 1 = 9 weightage)

Section C

Answer any **five** *questions.*
Each question carries 2 *weightage.*

22 Show that the packing factor of fcc lattice is $\frac{\pi\sqrt{2}}{6}$.

23 The Raman line associated with a vibrational mode which is both Raman and infrared active is found at 4600 Å when excited by a light of wavelength 4358 Å. Calculate the wavelength of the corresponding infrared band.

24 The first line in the rotation spectrum of carbonmonoxide has a frequency of 3.8424 cm^{-1}. Calculate the rotational constant and hence the C-O bond length in carbonmonoxide. Avogadro number is 6.022×10^{23}.

25 Discuss d.c and a.c. Josephson's effects and explain their importance.

26 The critical temperature, T_c for mercury with isotopic mass 199.5 is 4.185 K. Calculate its critical temperature when its isotopic mass changes to 230.4.

27 A relative population, or Boltzmann ratio, of 1/*e* is often considered representative of the ratio of populations in two energy states at room temperature, T = 360K. Determine the wavelength of the radiation emitted at that temperature.

28 Determine the wavelength associated with an electron having kinetic energy equal to 1 MeV.

(5 × 2 = 10 weightage)

Section D

Answer any **two** *questions.*
Each question carries 4 *weightage.*

29 Derive Bragg's law for X-ray diffraction in crystals. How is it verified ? Describe and explain X-ray spectrometer method of determining λ of X-rays.

30 Explain with a schematic diagram the working of a He-Ne laser.

31 Describe an experimental arrangement to study Raman effect. How is Raman scattering different from Compton's scattering ?

(2 × 4 = 8 weightage)

C 1754 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH/APRIL 2016

(UG—CCSS)

Physics

PH 6B 17—SOCIAL STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

(2013 Admissions)

Time : Three Hours Maximum : 30 Weightage

Section A (Objective Type Questions)

Answer **all** *questions.*
Each question carries ¼ weightage.

1. Is Braggs law satisfied by visible light for reflections from the different planes in a crystal ?

   (a) Yes. (b) No.

   (c) Depends on velocity. (d) Data insufficient.

2. The positions of four Cl atoms in a NaCl crystal are :

   (a) (1/2, 1/2, 1/2) (0, 0, 1) (1, 0, 0) (1/2, 0, 1/2).

   (b) (1/2, 1/2, 1/2) (0, 0, 1/2) (1/2, 0, 0) (0, 1/2, 0).

   (c) (1/2, 0, 1/2) (1/2, 0, 1/2) (1, 1, 1) (0, 0, 1).

   (d) (1/2, 1/2, 1/2) (1/2, 0, 0) (1/2, 0, 1/2) (0, 0, 1/2).

3. The diamond structure unit cell is :

   (a) fcc. (b) bcc.

   (c) Simple cubic. (d) Base centered cubic.

4. Attractive electrons inside a superconductors are called :

   (a) BCS pair. (b) Exitons.

   (c) Cooper pair. (d) Magnons.

5. Which of the following does not affect the width of the spectral lines ?

   (a) Collision broadening. (b) Doppler broadening.

   (c) Heisenberg uncertainty principle. (d) None of these.

6. Water molecule is :

   (a) Linear. (b) Symmetric top.

   (c) Spherical top. (d) Asymmetric top.

Turn over

7. For rotational energy levels :

   (a) They are equally spaced.

   (b) The difference between successive levels form an arithmetic progression.

   (c) They are unevenly spaced.

   (d) None of these.

8. For a vibrating rotor, which expression is correct ?

   (a) $E_{total} = E_{rot}\, E_{vib}$. (b) $E_{total} = E_{rot} + E_{vib}$.

   (c) $E_{total} = (E_{rot})^2\, E_{vib}$. (d) $E_{total} = E_{rot}\, (E_{vib})^2$.

9. The selection rule of pure rotational Raman spectra of linear molecules is :

   (a) $\Delta J = 0$. (b) $\Delta J = 2$.

   (c) $\Delta J = -2$. (d) $\Delta J = 0$ or $+/-2$.

10. Which of the following is not a property of LASER beam ?

    (a) Monochromatic. (b) Coherent.

    (c) Highly intense. (d) High divergence.

11. The value of ratio of Einstein's coefficients A_{21}/B_{21} is proportional to :

    (a) ν. (b) ν^2.

    (c) ν^3. (d) None of these.

12. Spectrum of sodium is an :

    (a) Emission spectrum. (b) Absorption spectrum.

    (c) Band spectrum. (d) None of these.

(12 × ¼ = 3 weightage)

Section B (Short Answer Type Questions)

Answer **all** *questions.*
Each question carries 1 *weightage.*

13. Give two symmetry elements of a cubic crystal.

14. What is a primitive lattice ?

15. Write any application of superconductivity.

16. Explain how a spectrum is produced ?

17. Give any *one* information that can be obtained from a rotation spectrum.

18. What is Born-Oppenheimer approximation ?

19. What is meant by polarizability ellipsoid ?

20. Explain the concept of stimulated emission.

21. Write any two applications of LASER beams.

(9 × 1 = 9 weightage)

Section C (Short Essay/Paragraph Questions)

Answer any **five** *questions.*
Each question carries 2 *weightage.*

22. Find the interplaner distance of NaCl crystal which produces 1st order diffraction pattern at an angle 30° when X-rays of wavelength 0.05 nm are used.

23. A sample of chromium is analysed by X-ray diffraction using Cu-Kα radiation with $\lambda_{K\alpha}$ = 1.5418 A°. Determine the Miller indices of the plane from which the angle of reflection is 31.4°. The lattice constant of Chromium is 2.96 A°.

24. The critical temperature for mercury with isotopic mass 199.5 amu is 4.185 K. Calculate its critical temperature when its isotopic mass changes to 203.4 amu. The isotopic effect coefficient is 0.5.

25. An excited electronic state has a life time of 10^{-8} s. Find the uncertainty in the radiation frequency.

26. Which of the following molecules shows a microwave rotation spectrum ? H_2, HCl, CH_4, H_2O. Explain.

27. Calculate the rotational constant HCl molecule having bond length 136 pico meter.

28. Draw the first five vibrational levels of a molecule, assuming its vibrations are of harmonic nature.

(5 × 2 = 10 weightage)

Section D (Essay Questions)

Answer any **two** *questions.*
Each question carries 4 *weightage.*

29. Explain the basic ideas of BCS theory of superconductivity. Describe the Meissner effect in super-conductors.

30. Discuss the instrumentation used for microwave spectroscopy.

31. Explain the principle and working of a ruby laser.

(2 × 4 = 8 weightage)

C 1753 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH/APRIL 2016

(UG—CCSS)

Core Course—Physics

PH 6B 17—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

(2009—2012 Admissions)

Time : Three Hours Maximum : 30 Weightage

Part A

Answer **all** *questions.*

Each question carries ¼ weightage.

1. The number of lattice points in a primitive cell are :

   (a) 2. (b) 1.

   (c) 3/2. (d) 1/2.

2. Which of the following metal crystallizes in fcc structure ?

   (a) Sodium. (b) Calcium.

   (c) Aluminium. (d) Zinc.

3. The miller indices of the plane parallel to x and y-axes are :

   (a) (001). (b) (100).

   (c) (111). (d) (010).

4. Soft super conductors observe :

   (a) Meissner effect. (b) Silsbee's rule.

   (c) Both (a) and (b). (d) Bragg's law.

5. The width of the energy gap of a superconductor at OK is :

   (a) $K_B T_C$. (b) $3.5\ K_B T_C$.

   (c) 0. (d) $2\ K_B T_C$.

6. A superconducting material when placed in a magnetic field will :

   (a) Does not influence the magnetic field.

   (b) Attract the magnetic field towards the centre.

   (c) Attract the magnetic field but transfer it into a concentrated zone.

   (d) Repel all the magnetic lines of force passing through it.

Turn over

7. The spontaneous emission is prominent the :

(a) Ultraviolet region. (b) Visible region.

(c) Infrared region. (d) Far infrared region.

8. Infrared spectroscopy provides valuable information about :

(a) Molecular weight. (b) Melting point.

(c) Conjugation. (d) Functional groups.

9. At the lowest vibrational level, the vibrational energy is :

(a) Zero. (b) 13.6 eV.

(c) Not zero. (d) Infinity.

10. Raman effect refers to the ——— of electromagnetic radiation.

11. The typical wavelengths emitted by diatomic molecules in the purely rotational transitions lies in the region of ———.

12. Laser action cannot take place without ———.

(12 × ¼ = 3 weightage)

Part B

Answer **all** *questions.*

Each question carries 1 *weightage.*

13. Define crystal lattice, basics and crystal structure.

14. Explain the terms Primitive cell and Unit cell.

15. What are super conductors? Give the important applications of superconductivity.

16. How does superconducting transition temperature vary with magnetic field ?

17. What is a symmetric top ? Give an example.

18. What is nuclear quadrupole moment ? Give its significance.

19. Why are the alternate lines of P and R branches of acetylene less intense ?

20. What is Raman scattering ?

21. Explain optical pumping.

(9 × 1 = 9 weightage)

Part C

Answer any **five** *questions.*

Each question carries 2 *weightage.*

22. Describe the characteristics of the four lattice types of the orthorhombic system.

23. Explain the characteristics of *bcc* and *fcc* lattices with examples.

24. What is lattice constant ? Calculate the lattice constant of NaCl given molecular weight of NaCl = 58.45 and density = 2.17×10^3 kg/m^3. Avogardo Number = 6×10^{26}.

25. Explain the factors affecting the width and intensity of spectral lines.

26. Explain why anti stokes lines are less intense than stoke's lines. Give the advantages of using laser on Raman source.

27. Explain why a two level laser is not possible.

28. What are hot hands ? Why are they called so ?

(5 × 2 = 10 weightage)

Part D

Answer any **two** *questions.*
Each question carries 4 *weightage.*

29. What are miller indices ? Draw neat diagrams to indicate miller indices of the important plane system in a simple cubic crystal. Obtain the relation between the interplanar spacings and cube edge.

30. Describe the Bragg's spectrometer and explain how it is used to determine the wavelength of X- rays. Calculate the wavelength of X- ray beam incident at 12 degrees for the first order reflection from a calcite crystal if the inner atomic spacing '*d*' for the crystal is 3.035 A degrees.

31. Explain the construction and working of : (a) Ruby laser ; and (b) Semiconductor laser.

(2 × 4 = 8 weightage)

C 80034 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH/APRIL 2015

(U.G.–CCSS)

Core Course—Physics

PH 6B 17—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours Maximum : 30 Weightage

Section I

Answer **all** *questions.*

Each question carries ¼ weightage.

1. Solids that have no periodic structure are called :
   (a) Amorphous. (b) Liquid crystals.
   (c) Simple cubic. (d) None of the above.
2. An example of a hexagonal system is :
   (a) NaCl. (b) $CuSO_4$.
   (c) Quartz. (d) $NiSO_4$.
3. Planes with equal intercepts on a and b axes and parallel to c axes are designated by :
   (a) [0 0 1]. (b) [0 1 0].
   (c) [0 1 1]. (d) [1 1 0].
4. Bragg's reflection can occur only for wavelength :
   (a) $\lambda \leq 2d$. (b) $\lambda \geq 2d$.
   (c) $\lambda \geq \frac{d}{\sqrt{2}}$. (d) $\lambda \leq \frac{d}{\sqrt{2}}$.
5. SQUIDS are used to defect :
   (a) Radiation from human body.
   (b) Small magnetic fields in a human brain.
   (c) Small electric fields in a human brain.
   (d) Heart beat.
6. Molecular absorption takes place :
   (a) At a single frequency. (b) Over a spread of frequencies.
   (c) At a discrete energy level. (d) None of the above.

7. When all the three principal moments of inertia of a molecule are equal, it is called ?
   (a) Symmetric top. (b) Linear molecule.
   (c) Spherical top. (d) Asymmetric top.
8. Raman lines are strongly ————.
9. The method of producing population inversion is called ————.
10. At the lowest vibrational level, the vibrational energy is :
   (a) Continuous. (b) Infinity.
   (c) Zero. (d) Non zero.
11. The three dimensional high speed photography method developed using lasers is called ————.
12. In Born oppenheimer approximation, we consider that a diatomic molecule can execute :
   (a) Rotations alone.
   (b) Vibrations alone.
   (c) Rotations and Vibrations independently.
   (d) None of the above.

(12 × ¼ = 3 weightage)

Section II

Answer **all** *questions.*
Each question carries 1 *weightage.*

13. What is a unit cell ?
14. Explain Bravais lattice in two dimensions.
15. Copper has an fcc structure with lattice constant $a = 3.61\text{Å}$. Calculate the radius of the copper atom.
16. What is a body centered cubic crystal ?
17. How can super conductivity be destroyed ?
18. What is centrifugal distortion ?
19. What is Raman resonance spectroscopy ?
20. Give the principle of working of a maser.
21. Why don't homonuclear diatomic molecules show vibrational spectra ?

(9 × 1 = 9 weightage)

Section III

Answer any **five** *questions.*
Each question carries 2 *weightage.*

22. What is miller indices ? Explain the rules to find the miller indices of a plane.

23. What do you understand by space lattice ? Enumerate the crystal systems.

24. Distinguish between type I and type II superconductors.

25. The moment of inertia of the Co molecule is 1.46×10^{-46} kg-m^2. Calculate the energy in eV.

26. Explain the effect of anharmonicity on the vibrational spectra of diatomic molecules.

27. The lines in the pure rotational 341 Mu spectrum of HCl are spaced at 20.8×10^3 per metre. Calculate the moment of inertia and internuclear distance. Mass of chlorine = 58.5×10^{-27} kg and mass of proton = 1.67×10^{-27} kg.

28. What are Einstein's coefficients ? Give the relation between them.

(5 × 2 = 10 weightage)

Section IV

Answer any **two** *questions.*
Each question carries 4 *weightage.*

29. What is Raman effect ? Explain theoretically the observed characteristics of the Raman spectra of a diatomic molecule. Bring out the similarity in infra red and Raman spectra.

30. What is super conductivity ? Explain Meissner effect of superconductivity. Give *two* important applications of superconductivity. The critical temperature of a superconductor when no magnetic field is present is T_c. Find the temperature at which the critical field becomes half its value of OK.

31. Derive expressions for the energy and frequency of diatomic molecule. Show the vibrational energy levels graphically.

(2 × 4 = 8 weightage)

C 60118 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH 2014

(U.G.—CCSS)

Physics

PH 6B 17—SOLID-STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours Maximum : 30 Weightage

I. Objective Type Questions : Answer *all* questions.

1 The co-ordination number for the case of simple cubic crystal structure is :

(a) 12. (b) 6.

(c) 2. (d) 1.

2 X-rays can be deflected by :

(a) Magnetic field. (b) Electric field.

(c) None of these.

3 How many molecules are there in the unit cell of NaCl ?

4 A superconductor which exhibit complete Meissner effect is called ————.

5 The width of energy gap of a superconductor at OK is about :

(a) OJ. (b) $3.5\ K_B T_C$.

(c) $1\ K_B T_C$. (d) $300\ K_B\ T_C$.

6 Choose the term which is not related with laser :

(a) Population inversion. (b) Metastable state.

(c) Meissner effect. (d) Optical pumbing.

7 The frequency range corresponds to X-ray spectrum is ———— Hz.

(a) $3\times10^{10} - 3\times10^{12}$. (b) $3\times10^{12} - 3\times10^{14}$.

(c) $3\times10^{14} - 3\times10^{16}$. (d) $3\times10^{16} - 3\times10^{18}$.

8 For a linear molecule :

(a) $I_a < I_b < I_c$. (b) $I_a = 0 \quad I_b = I_c$.

(c) $I_a \neq I_b \neq I_c$. (d) $I_a = I_b < I_c$.

Turn over

9 In a diatomic vibrating rotator, spectral lines corresponds to $\Delta J = +1$ are called ————.

10 The lines on the high frequency side of Raman spectra are called ————.

11 Energy of a photon of frequency 10^{10} Hz is ————.

12 The transition temperature of mercury is ————.

(12 × ¼ = 3 weightage)

II. Short Answer Type Questions : Answer all *nine* questions :

13 Explain the term primitive cell.

14 What is meant by co-ordination number ?

15 What happens to a superconductor when a strong magnetic field is applied ?

16 What is zero point energy ?

17 Write down two applications of LASER.

18 Give *two* examples for linear molecules.

19 What is Rayleigh line ?

20 Write down the equation for frequency of transitions between two adjacent lines in a vibrational spectra.

21 What is meant by metastable state ?

(9 × 1 = 9 weightage)

III. Short essay *or* paragraph questions : Answer any *five* questions from seven :

22 Calculate the atomic packing factor of fcc structure.

23 Using Quantum theory, explain Raman effect.

24 Write a note on symmetric top molecules.

25 Explain the properties of Laser beam.

26 Give a Schematic representation of a microwave spectrometer.

27 What is the average period of rotation of HCl molecule if it is in the J = 1 state. The internuclear distance of HCl is 0.1274 nm. Given mass of Hydrogen and Chlorine atoms are 1.673×10^{-27} kg and 58.06×10^{-27} kg respectively.

28 The fundamental band for HCl is centered at 2886 cm^{-1}. Assuming that the internuclear distance is 1.276 A°, calculate the wave number of the first two tines of each of the 'P' and 'R' branches of HCl.

(5 × 2 = 10 weightage)

IV. Essay questions : Answer *two* questions from three :

29 Explain the width and intensity of spectral transitions.

30 Explain Ruby Laser with a neat diagram.

31 Write a note on directions and planes of crystals and the determination of Miller indices.

(2 × 4 = 8 weightage)

C 40404 (Pages : 3) Name.....

Reg. No.....

SIXTH SEMESTER B.Sc. DEGREE EXAMINATION, MARCH 2013

(CCSS)

Physics

PH 6B 17—SOLID STATE PHYSICS, SPECTROSCOPY AND LASER PHYSICS

Time : Three Hours Maximum : 30 Weightage

Answer all **twelve** *questions.*
Each question carries ¼ weightage.

I. Objective type questions :

1 The number of lattice points in a primittive cell is ———.

(a) 1. (b) 2.

(c) $1/\sqrt{2}$. (d) $3/2$.

2 The co-ordination number for the case of simple cubic crystal structure is :

(a) 12. (b) 6.

(c) 2. (d) 1.

3 A Superconductor which exhibit complete Meissner effect is called ———.

4 How many atoms are present in the unit cell of hcp structure ?

5 Coherence length of paired electrons is.

(a) 0.25 nm. (b) 250 nm.

(c) 00.01 nm. (d) 0.001 nm.

6 Choose the term which is not related with laser.

(a) Population inversion. (b) Metastable state.

(c) Meissner effect. (d) Optical Pumbing.

7 The frequency range corresponds to IR spectrum is ——— Hz.

(a) $3\times10^{6}-3\times10^{10}$. (b) $3\times10^{12}-3\times10^{14}$.

(c) $3\times10^{14}-3\times10^{16}$. (d) $3\times10^{16}-3\times10^{18}$.

8 For a linear molecule :

(a) $I_a < I_b < I_c$.

(b) $I_a = 0 ; I_b = I_c$.

(c) $I_a \neq I_b \neq I_c$.

(d) $I_a = I_b < I_c$.

9 In a diatomic vibrating rotator, spectral lines corresponds to $\Delta J = +1$ are called ———.

10 The value of rotational constant B is :

(a) $\frac{h}{8\pi^2 Ic}$.

(b) $\frac{h^2}{8\pi^2 Ic}$.

(c) $\frac{h}{8\pi^2 I^2 c^2}$.

(d) $\frac{h^2}{8\pi^2 I^2 c^2}$.

11 The lines in the low frequency side of Raman spectrum are called ———.

12 The transition temperature of mercury is ———.

(12 × ¼ = 3 weightage)

II. Short answer type questions. (Answer all *nine* questions)

13 What is atomic packing factor ?

14 Explain the term primitive cell.

15 What is zero point energy ?

16 What are Bravais space lattices ?

17 What are hot bands ?

18 Write two applications of laser.

19 Explain Raman effect.

20 What is population inversion ?

21 Write two differences between laser beam and ordinary light beam.

(9 × 1 = 9 weightage)

III. Short essay or Paragraph questions. (Answer any *five* questions from seven) :

22 Calculate the packing factor of diamond cubic structure.

23 Write a note on Symmetric top molecules.

24 What are Miller indices ? What are their significance ?

25 Explain the crystal structure of NaCl.

26 Give a Schematic representation of a microwave spectrometer.

27 The fundamental band for HCl is centered at 2886 cm^{-1}. Assuming that the inter nuclear distance is 1.276 A° calculate the wave number of the first two lines of each of the '*p*' and 'R' branches of HCl.

28 Explain Collision broadening and Doppler broadening.

(5 × 2 = 10 weightage)

IV. Essay questions. (Answer *two* questions from three)

29 Explain Bragg's law and Bragg's X-ray Spectrometer.

30 Explain rotational energy levels and rotational vibrational transitions of a diatomic molecule.

31 Explain the theory and working of Ruby laser.

(2 × 4 = 8 weightage)