RAMAKRISHNA MISSION VIDYAMANDIRA

(Residential Autonomous College affiliated to University of Calcutta)

B.A./B.Sc. THIRD SEMESTER EXAMINATION, DECEMBER 2019

SECOND YEAR [BATCH 2018-21]

Date : 11/12/2019 **INDUSTRIAL CHEMISTRY (Honours)**

Time : 11 am – 3 pm **Paper : III** Full Marks : 75

(Use a separate Answer Book for <u>each group</u>)

Group-A

Answer **<u>any five</u>** questions from Question **Nos. 1 to 8**: [5×5]

1. i) Write down the energy expression for simple harmonic oscillator.

   ii) Calculate the difference in energy between two successive levels.

   iii) What is the essential condition for a light-induced vibrational transition? [1+2+2]

2. i) The vibrational energy level of F_2 molecule is given by the expression $E_V\left(cm^{-1}\right) = 215\left(v+\frac{1}{2}\right)\left[1-0.003\left(v+\frac{1}{2}\right)\right]$ find (i) the an harmonicity constant (ii) equilibrium oscillation frequency (iii) zero point energy

   ii) Derive the expression for the vibrational state which hosts the largest fraction of population. [3+2]

3. i) Calculate the frequency of light which induces a vibrational transition in terms of the frequency of vibration for such an oscillator between two successive levels.

   ii) The rotational spectrum of $^{79}Br^{19}F$ shows a series of equidistant lines 0.71433 cm^{-1} apart. Calculate the bond length of the molecule. [2+3]

4. In a labelled Jablonisky diagram show the possible processes through which an excited electronic state may be de-excited (all possible radiative and non-radiative paths). [5]

5. i) Which of the following molecules exhibit vibrational Raman but not infrared spectra.

   O_2, HCN, NO, CO_2

   ii) Derive the expression for the rotational state which hosts the largest fraction of population. [2+3]

6. i) In a triatomic molecule of type MX_2, two infrared and one Raman frequencies are observed. Indicate the structure of the molecule.

   ii) Calculate the frequency of light which induces a rotational transition in terms of the parameters of rotational motion.

   iii) What is the selection rule for a light-induced rotational transition? [2+2+1]

7. Give a schematic diagram for the spectroscopic arrangement for studying absorption and emission spectra with appropriately labelling. [5]

8. i) why phosphporescenece is less intense and always appear late compared to fluorescence?

   ii) Why we generally study emission spectroscopy in connection to electronic transitions, rarely for vibrational transitions almost never for rotational transitions? [3+2]

Group-B

Answer **any five** questions from Question **Nos. 9 to 16**: [5×5]

9. a) Distinguish between crystalline and amorphous materials with examples.

   b) Define 'lattice' and 'basis'. Correlate between 'lattice', 'basis' and 'crystal structure'. (2+3)

10. a) In a tetragonal lattice, define the following directions— i) [111] ii) $\left[2\bar{1}0\right]$.

    b) In a hexagonal lattice, indicate the following planes. i) $\left(11\bar{2}0\right)$, ii) $\left(\bar{1}101\right)$.

    c) What are the individual planes is a tetragonal lattice, belongs to $\{100\}$ family. (2+2+1)

11. a) Calculate the structure factor for a FCC lattice and find the conditions for diffraction maxima.

    b) An XRD experiment with Cu K_α radiation $\left(\lambda = 1.54\,\mathring{A}\right)$, using a diffractometer on a crystal with lattice parameter $a = 3.51\mathring{A}$, where are the Miller indices of the planes with lowest and highest Bragg angle? (2+3)

12. a) Calculate the linear and planar densities of a BCC lattice along [111] and (111) respectively.

    b) Copper crystallizes in FCC type structure with a density 8.92 g/cc. Calculate the atomic radius based on hard sphere packing model. (2+3)

13. a) Establish the relations between Miller and Miller-Bravais indices in hexagonal system.

    b) What is the range of r_C/r_A (cation to anion radius ratio) for co-ordination number 3. Derive. (3+2)

14. a) Define Schottky and Frenkel defect with schematic diagrams.

    b) An alkali halide of molecular weight 74.6 g/mol having NaCl structure has interatomic distance 0.32 nm. Compute its density for i) 0.1% schottky defect; ii) 0.1% Frankel defect. (3+2)

15. a) Classify the different kind of structures with examples.

    b) The average degree of polymerization of PVC is 2000. Calculate its average molecular weight in g/mol. (3+2)

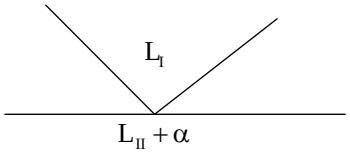
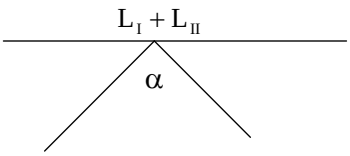
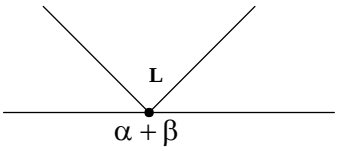
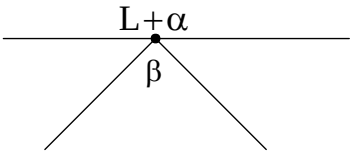
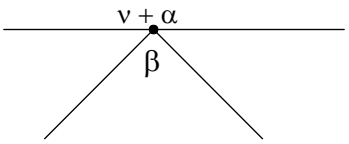
16. Describe necessary design and selection of phosphor materials for the development of white light emiting diode. (5)

Group-C

Answer **any five** questions from Question **Nos. 17 to 24**:

17. Draw the Fe-C phase equilibrium diagram and explain the salient points of diagram and explain the salient points of diagram upto 2.11% of carbon context only. (2.5×2)

18. Match column A to column B (1×5)

Name (A)	Phase boundaries near the invariant composition (B)
i) Eutectic	a) 
ii) Monotectic	b) 
iii) Peritectoid	c) 
iv) Syntectic	d) 
v) Peritectic	e) 

19. A blast furnace makes hot metal of 3 wt% C, 1.3% Si & other remainder in Fe. The following data are also given :—

    i) The ore contain 84% Fe_2O_3, the remainder being 16% gangue of SiO_2 & Al_2O_3.
    ii) The coke contains 84% fixed carbon & 16% Ash.
    iii) Coke consumption is 700 kg per tonne of hot metal.
    iv) Flux contains 94% $CaCO_3$ & the remainder is SiO_2 & its consumption is 450 kg/tonne hot metal.
    v) The blast furnace top gas contains a ration of $CO/CO_2 = 28/12$.

    Find out (per tonne of hot metal)

    a) The weight of ore used.

    b) The weight of slag made. (2.5+2.5)

20. For basic oxygen Furnace heat, the following data are given:—

    i) Hot metal contains 1% Si, 0.15% P, 0.25% Mn & 3.5% C

    ii) Weight of scrap in 10% of hot metal.

    iii) Steel at tap contains 0.2% C.

    iv) Slay has 54% CaO, 18% FeO,2.5% MgO, 2.5% MnO, CaO/SiO_2 ratio = 3.2.

    Calculate the following per tonne of steel.

    a) Weight of Hot metal charge.

    b) Quantity of lime required. (2.5+2.5)

21. a) Enumerate the relative merits and demerits of continuous casting system over ingot casting system.

    b) Why slidegate system is preferred to stoppshead assembly for teeming of molten steel? (2.5+2.5)

22. a) How refined lead is obtained from Lead bullion?

    b) How silver is recovered from its ore by cyanidadion process? (2.5+2.5)

23. Write short notes on **any two** of the following: (2.5+2.5)

    a) Soft solders and Brazing solders

    b) AOD converts process

    c) Stirring techniques in secondary steelmaking process.

24. a) Mention of the role of L.D 'ladle' in continuous casting of steel.

    b) Write short notes on solidification characteristics of continuously cast ingot. (2.5+2.5)

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