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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

UPES

End Semester Examination, December' 2017

Program: B.Tech MSNT
Subject (Course): Material Characterization II
Course Code : MTEG 342
No. of page/s: 3

Semester – V
Max. Marks : 100
Duration : 3 Hrs

Instructions:

1. **All questions are compulsory.**
2. **This question paper has three sections; Section A, Section B, and Section C**
3. **In section A there are total 5 questions, each carrying 4 marks**
4. **In Section B there are total 4 questions, each carrying 10 marks. Question no. 9 is having an internal choice.**
5. **In Section C there are total 2 questions, each carrying 20 marks. Question no. 11 is having an internal choice.**
6. **Draw suitable diagrams wherever required.**
7. **Your answer should be concise and to the point.**

Values of some physical constants:

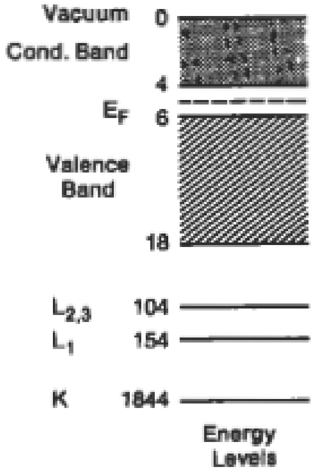
Velocity of light, $c = 3 \times 10^8 ms^{-1}$
Mass of electron, $m_e = 9.1 \times 10^{-31} kg$;
Rydberg constant (R_H)=109678 cm^{-1};
Planck's Constant (h) = $6.6 \times 10^{-34} J$sec;

Charge of electron, $e = 1.6 \times 10^{-19} C$
Mass of proton/neutron = $1.67 \times 10^{-27} kg$
Boltzmann Constant (K_B) =$1.38 \times 10^{-23} JK^{-1}$
1 a.m.u. = $1.67 \times 10^{-27} kg$

	SECTION A (All questions are compulsory)		
Ques 1	With suitable diagram explain the ideal tip geometry requirement for achieving the maximum resolution in a scanning tunneling microscope.	**[4]**	**CO1**
Ques 2	Discuss the step wise process of generating the topographic information of a surface when sample is scanned in an intermittent contact mode AFM.	**[4]**	**CO2**
Ques 3	The different regions of electromagnetic spectrum (in Hz) are given below; **X-rays**: 10^{18} *to* 10^{16} **Ultraviolet**: 10^{16} *to* 10^{14} **Visible**: 8×10^{14} *to* 3×10^{14} **Infrared (IR)**: 10^{14} *to* 10^{12} **Microwave**: 10^{12} *to* 10^{8} Evaluate the respective spectroscopic wave number (cm^{-1}) range.	**[4]**	**CO3**
Ques 4	The normal vibrational modes of CO_2 have two degenerate bending modes each with a frequency corresponding to 526 cm^{-1}. A light of frequency corresponding to 1052 cm^{-1} is used to excite the ground state of CO_2. According to harmonic oscillator model, what will be the outcome?	**[4]**	**CO3**

Table for Ques 3:

X-rays	**Ultraviolet**	**Visible**	**Infrared (IR)**	**Microwave**
10^{18} *to* 10^{16}	10^{16} *to* 10^{14}	8×10^{14} *to* 3×10^{14}	10^{14} *to* 10^{12}	10^{12} *to* 10^{8}

Ques 5	How many number of rotational (R), translation (T) and vibrational (V) degrees of freedom are available for: $C \equiv C - (C \equiv C)_n - C \equiv CH$. (Hint: write V in terms of n)	**[4]**	**CO4**
	SECTION B (All questions are compulsory)		
Ques 6	**(i)** If at the top of STM tip, two atoms are at same distance from sample surface what artifacts will be observed in image. **(ii)** An electron with a total energy of E_0= 5 eV approaches a potential barrier with a height of 10 eV. If the width of the barrier is 0.18 nm, evaluate the percentage change in probability when barrier height is doubled.	**[5+5]**	**CO1**
Ques 7	Elucidate the tip requirement and working of following non-topography imaging mode: “Electric force microscopy (EFM)”	**[10]**	**CO2**
Ques 8	**(i)** If one wish to design absorption experiment (IR, UV-Visible, Microwave etc), what are the main components required along with their desired properties. **(ii)** A diffraction grating has a ruled area that is 10 cm wide and 500 lines/ cm. Determine the resolving power and resolution in the 6th and 9th order for 33333 cm^{-1}.	**[5+5]**	**CO3**
Ques 9	**(i)** Elaborate on the analytical capabilities of X-ray photoelectron spectroscope (XPS) which makes it preferred tool for material characterization. **(ii)** Consider a C atom with ground state, first and second exited state binding energies of 290 eV, 20 eV and 10 eV respectively. Illustrate the XPS spectrum in both binding energy (BE) and kinetic energy (KE) scale assuming Al source (1486.6 eV). **OR** The figure shows the energy level diagram (binding energies are indicated (1844, 154, 104, 18, 6, 4, 0 eV)) of a solid Si. If Si is bombarded with 4 keV X-rays. Discuss all possible outcomes of the process along with their energies (Hint: Photoelectrons, Auger electrons, X-rays etc.) 	**[4+6]** **[10]**	**CO4**

	SECTION C (All questions are compulsory)		
Ques 10	**(i)** The SPM's can be used to manipulate atoms to form desired structures at the atomic level. Explain the process of atomic patterning using: **(a)** Scanning tunneling Microscopy **(b)** Dip-Pen Lithography **(ii)** Calculate the broadening $\Delta\nu$ of transitions in HCN at 25°C due to the Doppler effect in regions of the spectrum typical of rotational transitions (10 cm^{-1}), vibrational transitions (1500 cm^{-1}) and electronic transitions (60 000 cm^{-1}).	**[8+8+4]**	**CO1** **CO2** **CO3**
Ques 11	**(a)** Illustrate the normal modes of vibrations seen in a linear triatomic molecule using CO_2 as example. **(b)** Define selection rules and draw the microwave and Raman spectra for a diatomic molecule. Also discuss the origin of stokes and anti-stokes lines. **(c)** The separation between the first and second line in a microwave spectra of CO molecule (rigid rotor model) is 3.82 cm^{-1}. If same separation is obtained for H_2 molecule in Raman spectra. Evaluate the bond distance in both cases. **OR** **(a)** Highlight the major difference in terms of interaction with electromagnetic radiations in Infrared (IR) and Raman Spectroscopy. Also comment why rotational modes of H_2 molecule are observed in Raman spectra and not in microwave spectra. **(b)** What are the major drawbacks of harmonic model for diatomic molecule? Using an-harmonic (Morse) oscillator model explain different regions of Morse curve and draw the allowed energy levels and transitions.	**[8+8+4]** **[10+10]**	**CO4**