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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2014/2015

COURSE NAME	:	NANOSTRUCTURED MATERIALS
COURSE CODE	:	BWC 30903
PROGRAMME	:	3 BWC
EXAMINATION DATE	:	JUNE/JULY 2015
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS IN **SECTION A** AND SELECT **TWO** QUESTIONS IN **SECTION B.**

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

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SECTION A

Q1 (a) Explain in brief the fundamental science behind nanotechnology. Elaborate the differences between nanoparticles and bulk properties.

(8 marks)

(b) (i) Elaborate the differences between crystalline and amorphous solids. Briefly mention packing, the atoms or elements involved and surface morphology, complete with example of materials.

(9 marks)

(ii) Calculate the atomic packing density along [011] direction of aluminum (Al). Express your answer in units of atoms cm^{-1}.

(8 marks)

Q2 (a) In a recent research done by a research group at École polytechnique fédérale de Lausanne (3^{rd} March 2015), they have fired a laser at a metallic nanowire, making charged particles inside the nanowires to vibrate as shown by TEM (Transmission Electron Microscope) image in **Figure 2(a).** They are the first group to prove the phenomena of "particle-wave dualism" through experiment and imaging tool. Please elaborate the meaning of "particle-wave dualism"? Name a famous scientist that first propose the "particle wave duality".

Note on their experiment: (condensed from the news):

Then comes the novel part -- the physicists shot a stream of electrons close to the nanowire. As those electrons interacted with the light source, hitting the confined photons, they either sped up or slowed down, and the microscope allowed the researchers to image the position where the change in speed -- and therefore the imaging the standing wave.

(9 marks)

(b) What is the most important fact about "particle-wave dualism"? Please explain the standing wave and how does a standing wave can be used to explain quantum phenomena? Use the image given to help you in your eleboration.

(8 marks)

(c) Calculate the Bohr radius for hydrogen states from $n = 1$ to $n = 3$. The formula to calculate Bohr orbital is as follow, and later sketch the standing wave in the given **Figure 2(b).**

$$r_n = \frac{\hbar^2 n^2}{m_e k e^2 Z} = \frac{a_0 n^2}{Z} = \frac{52.9 n^2}{Z} pm$$

(8 marks)

SECTION B

Q3

(a) Elaborate the process to fabricate nanoparticles either from the photolithography or Electron Beam Lithography (EBL) technique.

(9 marks)

(b) Describe the limitations in today's photolithography when it comes to decreasing the feature size.

(8 marks)

(c) What are the advantages and the disadvantages of EBL versus photolithography?

(8 marks)

Q4 (a) What kind of surface properties is needed to obtain a superhydrophobic surface?

(9 marks)

(b) Elaborate the uniqueness of Carbon and its materials.

(8 marks)

(c) Describe a technique to fabricate Carbon Nanotube.

(8 marks)

Q5 (a) Describe the operation of Fourier Transform Infrared Spectroscopy (FTIR) machine.

(9 marks)

(b) What is the advantages and the disadvantages of FTIR?

(8 marks)

(c) What can you explain from the FTIR spectrum shown in **Figure 5(c).**

(8 marks)

– **END OF QUESTION –**

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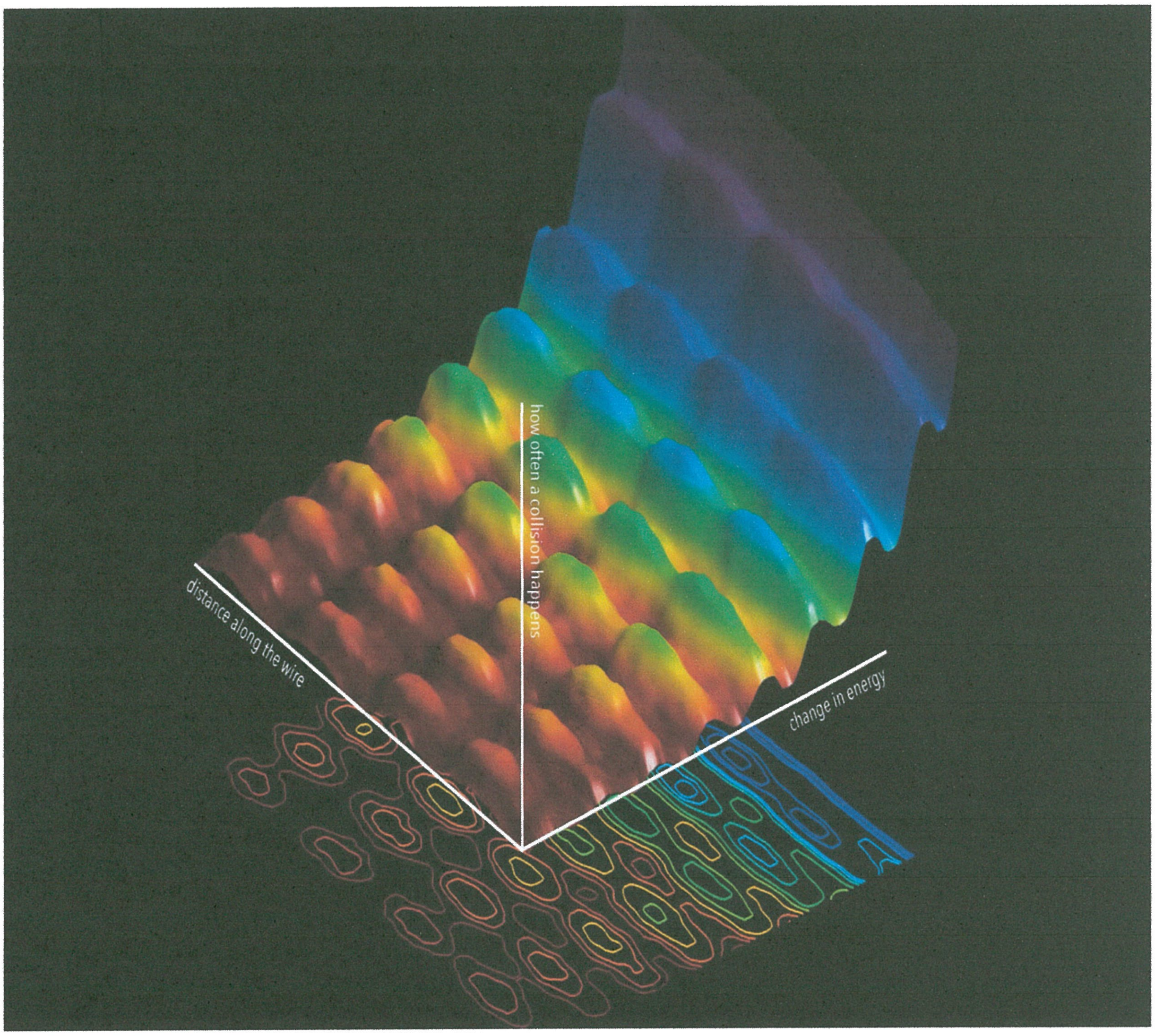

FIGURES Q2.(a)

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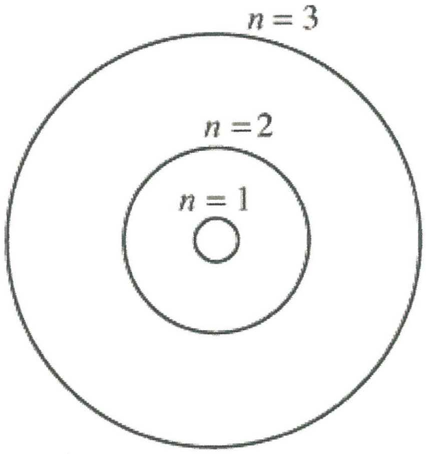
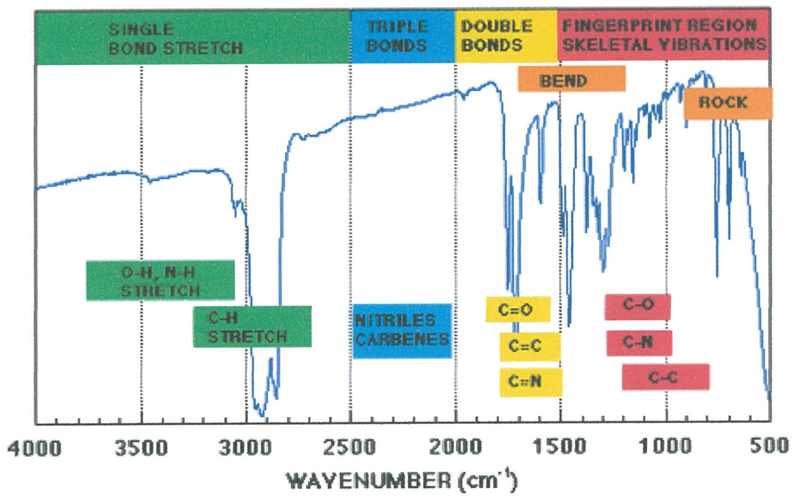
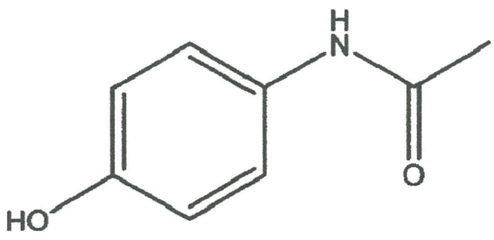


FIGURES Q2(b)





Paracetamol

FIGURE Q5(c): IR Spectrum of Paracetemol and its molecule.

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Constants

Quantity	Symbol	Value
Angstrom unit	Å	1 Å = 10^{-8} cm = 10^{-10} m
Avogadro number	N	6.023×10^{23}/mol
Boltzmann constant	k	8.620×10^{-5} eV/K = 1.381×10^{-23} J/K
Electronic charge	q	1.602×10^{-19} C
Electron rest mass	m_o	9.109×10^{-31} kg
Electron volt	eV	1 eV = 1.602×10^{-19} J
Gas constant	R	1.987 cal/mole-K
Permeability of free space	μ_o	1.257×10^{-6} H/m
Permittivity of free space	ε_o	8.850×10^{-12} F/m
Planck constant	h	6.626×10^{-34} J-s
Proton rest mass	m_p	1.673×10^{-27} kg
$h/2\pi$	$\hbar$	1.054×10^{-34} J-s
Thermal voltage at 300 K	V_T	0.02586 V
Velocity of light in vacuum	c	2.998×10^{10} cm/s
Wavelength of 1-eV quantum	λ	1.24 μm

– END OF QUESTION –