THE OPEN UNIVERSTY OF SRI LANKA

BACHELOR OF SCIENCE DEGREE PROGRAMME – LEVEL 05

FINAL EXAMINATION 2012/2013

BIOPHYSICS –PYU 3165/PYE 5165/PHU3152/PHE 5152

Duration: TWO HOURS (2 hrs)

Date 03rd June 2013 **Time 9.30a.m -11.30 a.m**

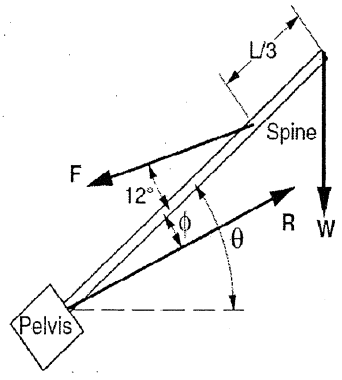
Answer Four (4) questions only.

Use the following values when necessary,
Plank's constant, $h_{-} = 6.63 \times 10^{-34}$ J s, charge of an electron, $e = 1.6 \times 10^{-19}$ C, mass of the electron, $m_e = 9.1 \times 10^{-31}$ kg , Speed of light $c = 3.0 \times 10^{8}$ m s^{-1}, 1eV = 1.6×10^{-19} J and 1 J =1 kg m^2 s^{-2}. Universal gas constant = R = 8.314 J $mol^{-1}K^{-1}$

1. (a) What are the three types of food that provide energy to a person? Describe the concept behind the measurement of energy expenditure using direct and indirect Calorimetry.

[10 Marks]

(b) Consider the forces on the spine when lifting. Approximate the spinal column as a stiff bar of length L that has three forces acting on it. **W** is the downward force acting at the top of the spinal column (via the arms and shoulders), and equals the weight of the object being lifted. **F** is the force applied by the erector spine muscle, which attaches to the spine about one-third of the way from the top of the column. Assume this muscle acts at an angle of 12° to the spinal column. **R** is the force the pelvis exerts on the spinal column. The weight of the trunk is neglected. Assume the spinal column makes an angle θ with the horizontal.



(i) Determine **R** and **F** in terms of **W** and **θ**. (Hint: Determine the components of R, along the spine and a direction perpendicular to that)

(ii) The spinal column may be injured if **R** is too large. Compare **R** when **θ** is 0°and 90°. This problem explains why people say to "lift with your legs, not with your back." Estimate ϕ when **θ** is 0° and 90°

[40 Marks]

(c) A 55 year old man can focus objects clearly from 100 cm to 300 cm. Representing the eye as a simple lens 2 cm from the retina,
(a) What is the focal length of the lens at the far point (focused at 300 cm)?
(b) What is the focal length of the lens at the near point (focused at 100 cm)?

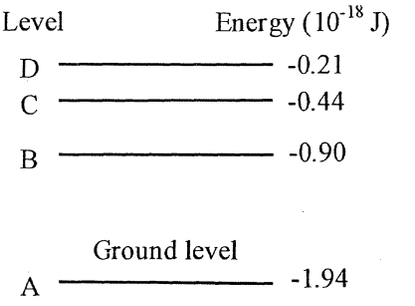
[25 Marks]

(d) A source emits sound energy uniformly in all direction. A sound level meter records 90 dB when situated 2.5 m from the source. Given that the threshold intensity of hearing (I_o) is 1.0×10^{-12} W m^{-2}, calculate the total sound power emitted by the source.

[25 Marks]

2. **(a)** (i) What is the de Broglie wavelength?

The diagram shows some of the electron energy levels of an atom.
An incident electron of kinetic energy 4.1×10^{-18} J and speed 3.0×10^{6} m s^{-1} collides with the atom represented in the diagram and excites an electron in the atom from level B to level D.



(ii) For the incident electron, calculate
(i) The kinetic energy in eV,
(ii) The de Broglie wavelength.

(iii) When the excited electron returns directly from level D to level B it emits a photon. Calculate the wavelength of this photon.

[25 Marks]

(b) What are the assumptions made by Bohr's theory of H –atom? Discuss briefly about the limitations of Bohr's theory.

[25 Marks]

(c) What are the three types of spectra of luminous bodies? In what respect the spectra of Hydrogen differs from the spectra of single ionized Helium?

[25 Marks]

(d) A doubly ionized Lithium atom is hydrogen like with atomic number 3.

(i) Find the wavelength of radiation required to excite the electron in Li^{++} from the first to the third Bohr Orbit. (Ionization energy of the hydrogen atom equals 13.6 eV).

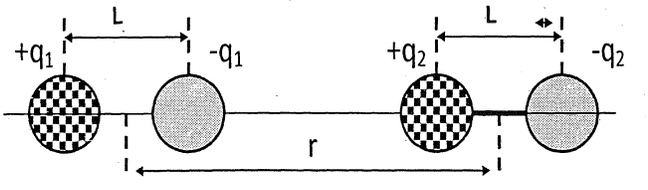
(ii) How many spectral lines are observed in the emission spectrum of the above excited system?

[25 Marks]

3. **(a)** Name three types of intermolecular forces with brief introduction which can be found in many biological molecules.

[20 Marks]

(b) Calculate the potential energy of interaction of two dipoles in the arrangement shown in following figure, when their separation is *r*.



Useful expansions, $\frac{1}{1+x} = 1 - x + x^2 - \cdots$ and $\frac{1}{1-x} = 1 + x + x^2 + \cdots$)

[25 Marks]

(c) Discuss the differences in the polarity of alcohol and water. Explain why water dissolves salt better than alcohol.

[25 Marks]

(d) A suspension of kaolin (a type of clay used as adsorbent for biological materials) in a liquid became clear upon being allowed to stand undisturbed for 30 minutes at 20 °C. The height of the suspension in the vessel was 30 cm and the density of kaolin is known to be 3.6 x 10^3 kg m^{-3}.

Estimate the **diameter** and the **sedimentation coefficient** of kaolin particles stating the assumptions you may use.

Given that the density of the liquid at 20 °C is 1.2 x 10^3 kg m^{-3} while its viscosity is 1.5x 10^{-3} N s m^{-2}. The acceleration due to the gravity is 10 m s^{-2} and the terminal velocity of a spherical particle in a viscous media (η) under the influence of gravity can be obtain from $V = 2r^2 (\rho-\sigma)g/ 9\eta$ where symbols have their usual meanings.

[30 Marks]

4. (a) A perfect black body radiates energy according to Stefan's Law, which states $E = \sigma T^4$ where E is the total energy radiated per unit area per second by a black body at temperature of T K and σ is a constant known as Stefan's constant . ($\sigma = 5.7 \times 10^{-8}$ W m^{-2} K^{-4})

In an experiment a black body initially at 27 °C is heated to 627 °C. How many times is the total radiation energy emitted at the higher temperature than it emitted at the lower temperature?

(20 marks)

(b) (i) State the first law of thermodynamics in differential form clearly defining the terms you use.

(ii) Define following three processes briefly and show them in a *P-V* diagram

(1)Adiabatic process (2) Isothermal process (3) Isobaric process.

(20 marks)

(c) Show that the work done on a gas as its volume changes from an initial value V_i to a final value V_f is

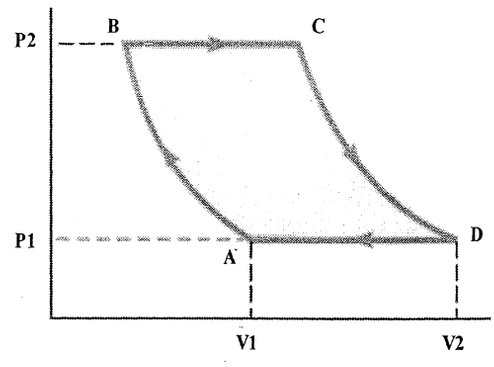
$W = -\int_{Vi}^{Vf} P\, dv$

where P is the pressure, which may vary during the process.

(20 marks)

(d) An ideal gas is carried through a thermodynamic cycle consisting of two isobaric and two isothermal processes as shown in Figure. Show that the net work done on the gas in the entire cycle is given by

$$W_{net} = -P_1 (V_2 - V_1) \ln \left(\frac{P2}{P1}\right)$$



[40 Marks]

5. (a) Explain the constructive interference and destructive interference. Give two requirements to observe the above interference patterns.

[20 Marks]

(b) Explain the phenomenon of the diffraction of light with a simple example

[20 Marks]

(c) With the aid of a labeled diagram, describe Young's double slit experiment and derive an expression for the path difference?

[20 Marks]

(d) In Young's double slit experiment the separation of the slits is 0.2 mm and fringes are observed on a screen placed 1 m away. It is found that with a certain source of light the forth bright fringe is 1 cm from the central fringe.
Calculate
(i) The wavelength of the light.
(ii) Fringe width
(iii) Path difference at the position of 4^{th} dark fringe and the 5^{th} bright fringe.

[40 Marks]

6. (a) (i) Using text and a labeled diagram, explain briefly how X-rays are produced.

(ii) Define the terms *"Crystal structure"*, *"Lattice"*, *"Primitive cell"* and *"Unit cell"* used in X-ray diffraction.

[20 Marks]

(b) (i) There are several techniques being used in X-ray diffraction experiments. Name three methods used more often in these experiments.

(ii) Discuss briefly how X-ray diffraction technique is used to determine protein structure.

[20 Marks]

(c) (i) Define Miller indices. Sketch the following atomic planes in a simple cubic structure, (100) and (111).

(ii) Obtain the miller indices of a plane which intercepts at *3a, 2b, 3c* in a simple cubic unit cell. Draw a neat diagram showing the plane.

[20 Marks]

(d) The first order reflection from the (111) planes of a simple cubic lattice is observed at 40◦ using radiation of wavelength λ = 0.18 nm. State Bragg's law and use it to calculate the interplaner separation of the (111) planes and the side length of the unit cube.

[40 Marks]

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