



Test Competition, The 3<sup>rd</sup> IJSO, São Paulo-Brazil, December 7, 2006

## THEORETICAL COMPETITION....UK & Ireland

December 7, 2006

**Read carefully the following instructions:**

1. The time available is 3 hours.
2. Check that you have a complete set of the test questions and the answer sheets.
3. Use only the pen provided.
4. Write down your name, country and signature in your answer sheet.
5. Read carefully each problem and write the correct answer **in your answer sheet**.
6. **All competitors are not allowed to bring any stationary and tools provided from outside.**  
**After completing your answers, all of the question and answer sheets should be put neatly on your desk.**
7. **Point rules :**  
According with each question marking.

## EXAMINATION RULES

1. All competitors must be present at the front of examination room ten minutes before the examination starts.
2. No competitors are allowed to bring any tools except his/her personal medicine or any personal medical equipment.
3. Each competitor has to sit according to his or her designated desk.
4. Before the examination starts, each competitor has to check the stationary and any tools (pen, eraser, ruler, sharpener, pencil, calculator) provided by the organizer.
5. Each competitor has to check the question and answer sheets. Raise your hand, if you find any missing sheets. Start after the bell.
6. The competitor must write down their name and country (in Latin characters) on the answer sheet. The answer must be written on one side of the answer sheet.
7. During the examination, competitors are not allowed to leave the examination room except for emergency case and for that the examination supervisor will accompany them.
8. *The competitors are not allowed to bother other competitor and disturb the examination. In case any assistance is needed, a competitor may raise his/her hand and the nearest supervisor will come to help.*



*Test Competition, The 3<sup>rd</sup> IJSO, São Paulo-Brazil, December 7, 2006*

9. There will be no question or discussion about the examination problems. The competitor must stay at their desk until the time allocated for the examination is over, although he/she has finished the examination earlier or does not want to continue working.
10. At the end of the examination time there will be a signal (the ringing of a bell). You are not allowed to write anything on the answer sheet, after the allocated time is over. All competitors must leave the room quietly. **The question and answer sheets must be put neatly on your desk.**

## THEORETICAL EXAMINATION.. U.K & Ireland

### Problem I. Physics (10 points)

In 1905, Albert Einstein introduced the idea that radiation in each frequency can only exist in multiples of a basic quantity (*quantum*). The carrier of this basic quantity was later called *photon*. The energy  $E$  carried by each individual photon is proportional to the frequency  $f$  of the radiation, with the proportionality constant being the Planck's constant  $h = 6.63 \times 10^{-34} \text{ J s}$ :

$$E = hf$$

For instance, the radiation of green light (with wavelength  $\lambda = c/f \sim 500 \text{ nm}$ ) is composed of photons with energy  $E \sim 2.5 \text{ eV}$ , while radiation of X-ray ( $\lambda = c/f \sim 1 \text{ nm}$ ) is composed of photons with energy  $E \sim 1.2 \text{ keV}$ . (Recall that  $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$  and the speed of light is  $c = 3.0 \times 10^8 \text{ m/s}$ .) With this concept in mind, and with the help of Figure 1, answer the following questions.

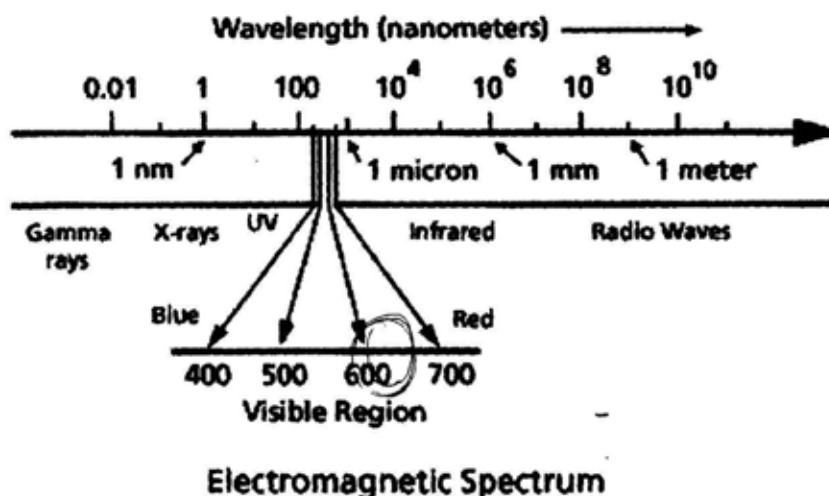


Figure 1

1. (3.5 points) Consider electrons accelerated through a difference of potential of 6000V in a vacuum tube. Then, these electrons are stopped by collision with a target plate. In this process, radiation is produced (known as *bremsstrahlung*).
  - a) (1.0 point) Calculate the energy of the radiation produced in J. (The elementary charge is  $e = 1.6 \times 10^{-19} \text{ C}$ .)
  - b) (0.5 points) What is the highest frequency of radiation produced in this process?  
Tick the correct box

Gamma ray	X-ray	UV light	Visible light	IR radiation	Radio waves
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- c) (2.0 points) Calculate the energy and speed of a proton if it were accelerated at this voltage.  
(The mass of a proton is  $m_p = 1.67 \times 10^{-27} \text{ kg}$ .)

2. (6.5 points) Consider the experimental apparatus of Figure 2. When the metallic plate  $B$  is illuminated with light of frequency  $f$  above a certain "critical" value  $f_c$  (which depends on the material of the plate  $B$ ), an electric current appears in the circuit. In order to *stop* this current, a difference of potential can be applied between plates  $A$  and  $B$ . The *minimum* value of the potential difference  $V_0$ , necessary to stop the current depends on the frequency  $f$  of the light illuminating  $B$ .

(a) (1.0 points) Obtain a theoretical relation between  $V_0$  and  $f$  for frequencies larger than  $f_c$ .

(b) (4.5 points) Given the following experimental data plot a graph of voltage (vertically) against frequency (horizontally).

$f$ in $10^{15}$ Hz	$V_0$ in V
3.0	4.3
4.0	8.3
5.0	12.1
6.0	16.9
7.0	21.1
8.0	24.1
9.0	29.3
10.0	33.0

Calculate the slope of the graph, and give the critical frequency  $f_c$ .

(c) (1.0 points) How can the existence of a "critical" value of frequency, below which this phenomenon does not occur, be interpreted in terms of photons or packets of energy? Tick the correct box(es).

The photon has too low energy	<input type="checkbox"/>
Not enough photons are produced	<input type="checkbox"/>
The wavelength of each photon is too short	<input type="checkbox"/>

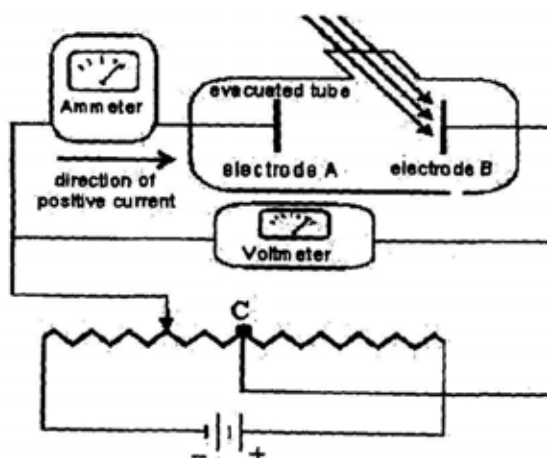
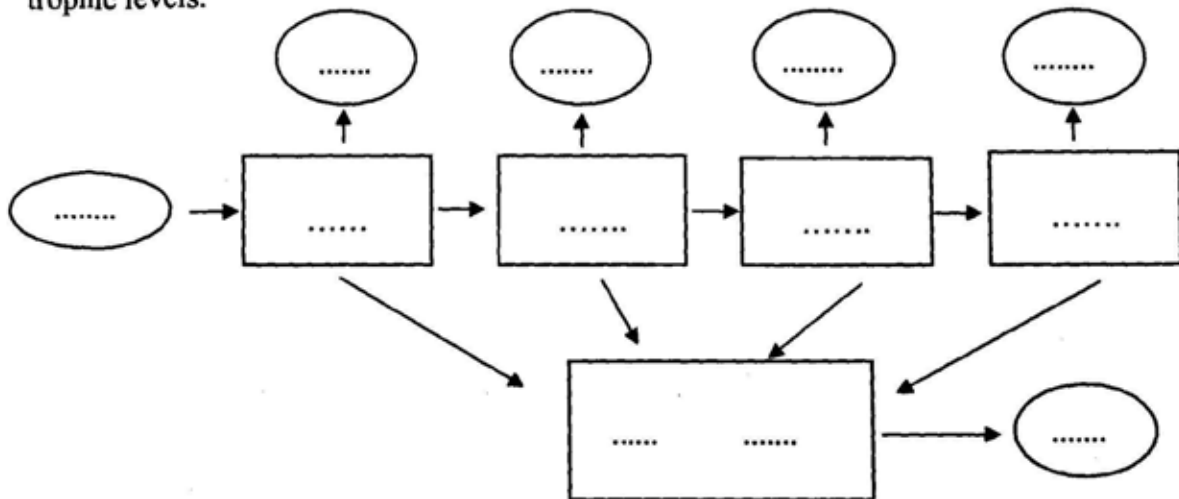


Figure 2

**Biology (10 points)**

**1- (2.5 points)** The figure below shows the energy flow for a food chain with several trophic levels.



**a) (8x0.125 point)**

Fill in the empty spaces in the diagram on your answer sheet using the following key:

1 = fungi, 2 = snake, 3 = heat, 4 = frog, 5 = bacteria, 6 = cricket, 7 = light, 8 = plant

The numbers may be used more than once.

**b) (5x0.25 point)**

Write in the boxes of the same diagram above the Roman numbers referring to following terms:

(I) = decomposer, (II) = producer, (III) = consumer

(Some numbers may be used more than once.)

**c) (0.25 point)**

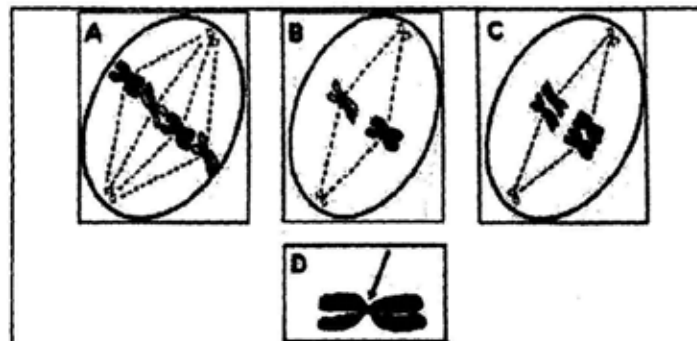
How many trophic levels are in this food chain? .....

2- (2.5 points) The drawings A, B, C show different stages of nuclear (cell) division. In this cell, the diploid number of chromosomes ( $2n$ ) is 4.

Key to be used for the questions a) and b):

1 = S phase	6 = homologous chromosomes	11 = interphase
2 = $G_1$ phase	7 = meiosis	12 = centrioles
3 = prophase	8 = telophase	13 = metaphase
4 = centromere	9 = metaphase I	14 = mitosis 有丝分裂
5 = anaphase	10 = metaphase II	15 = chromatids

(The numbers of the key can be used once or more than once.)

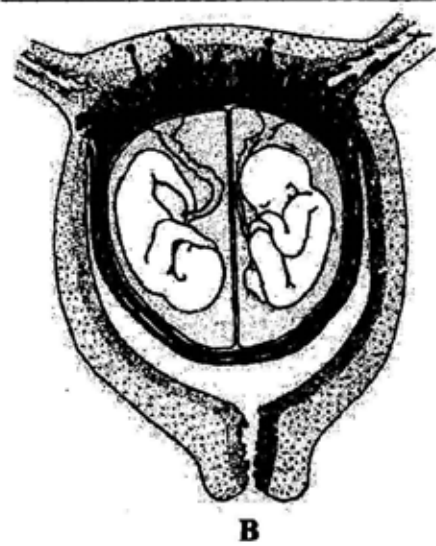
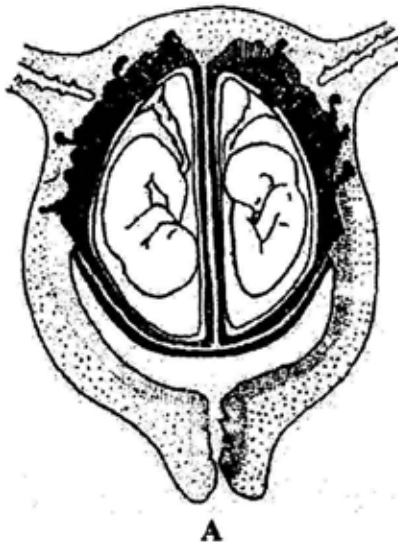


a) Fill in the table (in your answer sheet) with the correct numbers from the key above. (9x0.25 points)

	Type of nuclear (cell) division	Name of the stage shown	What will be separated in the next stage?
Figure A	_____	_____	_____
Figure B	_____	_____	_____
Figure C	_____	_____	_____

b) What is the name of the structure labelled D? Use the same key. .... (0.25 points)

3 - (2.5 points) The pictures A and B represent the uterus of two pregnant women.



a) Tick the type of twins in figures A and B(in your answer sheet) (1.0 point)

Types of twins	Figure A	Figure B
Monozygotic		
Dizygotic		
Trizygotic		

b) Tick the appropriate option in the following table in your answer sheet. Twins in the figures A and B could be: (1.0 point)

Options	Figure A	Figure B
Only same sex		
Only different sexes		
Maybe different sexes		

c) In the table (below in your answer sheet), tick the general functions of the placenta.  
(0.5 point)

Placental functions	Correct	Incorrect
1. Transfers oxygen, nutrients and hormones from the mother to the foetus		
2. Helps in the digestion of mother's food.		
3. Protection of the foetus against most pathogens.		
4. Filters out waste from the foetus		



4- (2.5 points) Consider the following eukaryotic cells: Amoeba, Paramecium, Euglena, Trypanosoma, spermatozoa and oviduct epithelial cells. Answer the following questions:

a) In the table below (in your answer sheet), tick the structures possessed by the different cells. (1.0 point)

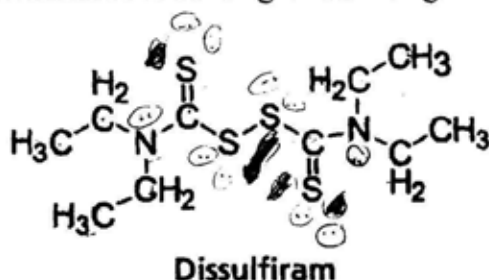
	Amoeba	Paramecium	Euglena	Trypanosoma	Spermatozoa	Oviduct Epithelial Cells
Cilia						
Flagella						
Pseudopodia						

b) In the table below,(in your answer sheet) tick the function(s) of these structures (cilia, etc) found in different cells. (1.5 points)

	Amoeba	Paramecium	Euglena	Trypanosoma	Spermatozoa	Oviduct Epithelial Cells
I- only to cause movement of media surrounding the cell						
II- only to cause movement of the cell						
III- Both I and II						

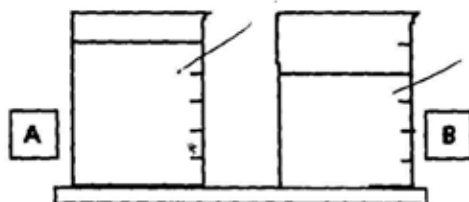
Chemistry (10 points)

1- (2.5 points) The medication *dissulfiram*, which has the following structural formula, has great social and therapeutic importance, because it is employed in alcoholism treatment. The correct dose administration causes intolerance to beverages containing ethanol.

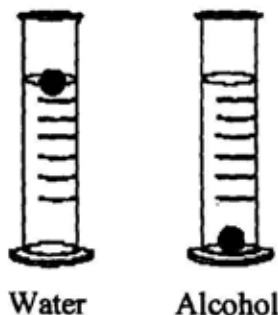


- (0.5 point) Write the *dissulfiram* molecular formula.
- (1.0 point) How many non-shared electron pairs are in this molecule?
- (1.0 point) Would it be possible to prepare a compound, like *dissulfiram*, where nitrogen atoms are replaced by oxygen atoms? Answer Yes or No.

2- (2.5 points) Two identical flasks are shown below. One of them contains 1 kg of water ( $H_2O$ ) and the other one, an equal mass of alcohol ( $CH_3CH_2OH$ ).



Using a small ball with appropriate density, the following experiment was done.



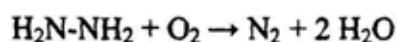
- (0.5 point) In which flask is water? A or B?
- (1.0 point) Considering both masses contained in flasks A and B, calculate how many **moles** are in flask A and B?
- (1.0 point) Proceeding as in item b, establish how many **atoms** are in flask A and B.  
Avogadro's number =  $6.02 \times 10^{23}$   
(C =  $12 \text{ g mol}^{-1}$ , H =  $1 \text{ g mol}^{-1}$ , O =  $16 \text{ g mol}^{-1}$ )

3 - Zeppelins were the biggest flying device made by men. The greatest one, "Hindenburg" employed hydrogen, instead of helium. The balloon was 250 meters long, and its volume was about  $200 \times 10^6$  liters, corresponding to  $8.1 \times 10^6$  moles of gas. However, hydrogen is highly combustible, and this caused Hindenburg's explosion in May, 6 of 1937.

a) (0.5 point) Write the chemical reaction for hydrogen combustion.

b) (2.0 points) If the hydrogen of Hindenburg was obtained from reaction of iron with acid (resulting in  $\text{Fe}^{2+}$ ), calculate the mass of iron which would be necessary and show the corresponding balanced equation.

4 - (2.5 points) Hydrazine is used as a rocket fuel. Its combustion can be represented by the following reaction.



The enthalpy change of this reaction can be obtained through the enthalpy of the bonds involved. Thus, we consider energy liberation when a bond is formed and energy absorption when a bond is broken. The table below shows enthalpy (bond energy) for each mole of broken bonds.

Bond	Enthalpy (kJ/mol)
H-H	436
H-O	464
N-N	163
N=N	514
N $\equiv$ N	946
C-H	413
N-H	389
O=O	498
O-O	134
C-O	799

What is the enthalpy change for combustion of one mole of hydrazine?



Experimental Examination, The 3<sup>rd</sup> IJSO, São Paulo, December 7, 2006

**THEORETICAL EXAMINATION ---UK & Ireland**  
**December 7, 2006**

**Answers Sheet**

Name:
Country:
Signature:

**Physics**

1) (3.5 points)

a) (1.0 point)

b) (0.5 point)

Gamma ray	X-ray	UV light	Visible light	IR radiation	Radio waves

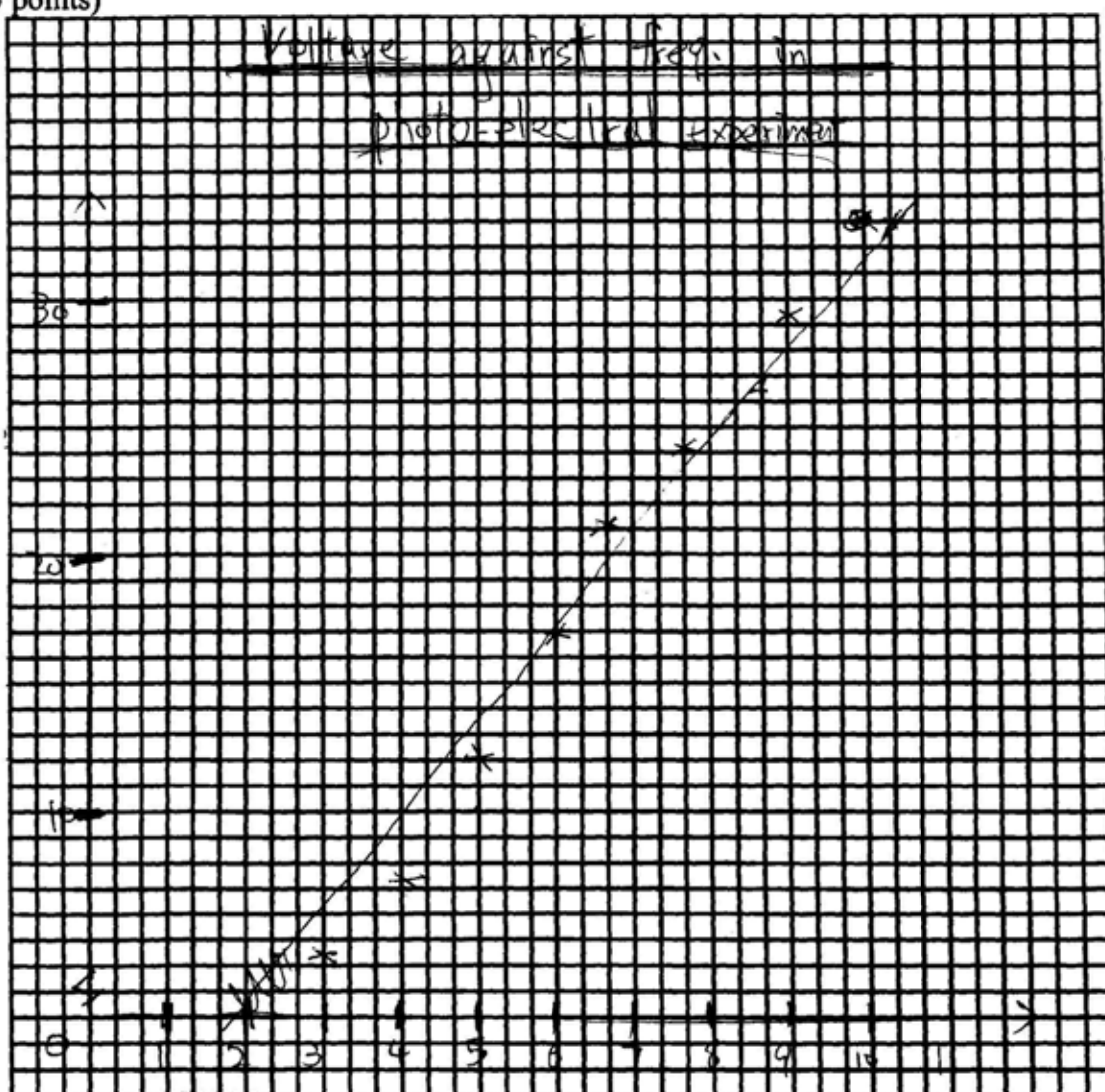
c) (2.0 points)



2) (6.5 points)

a) (1.0 point)

b) (4.5 points)



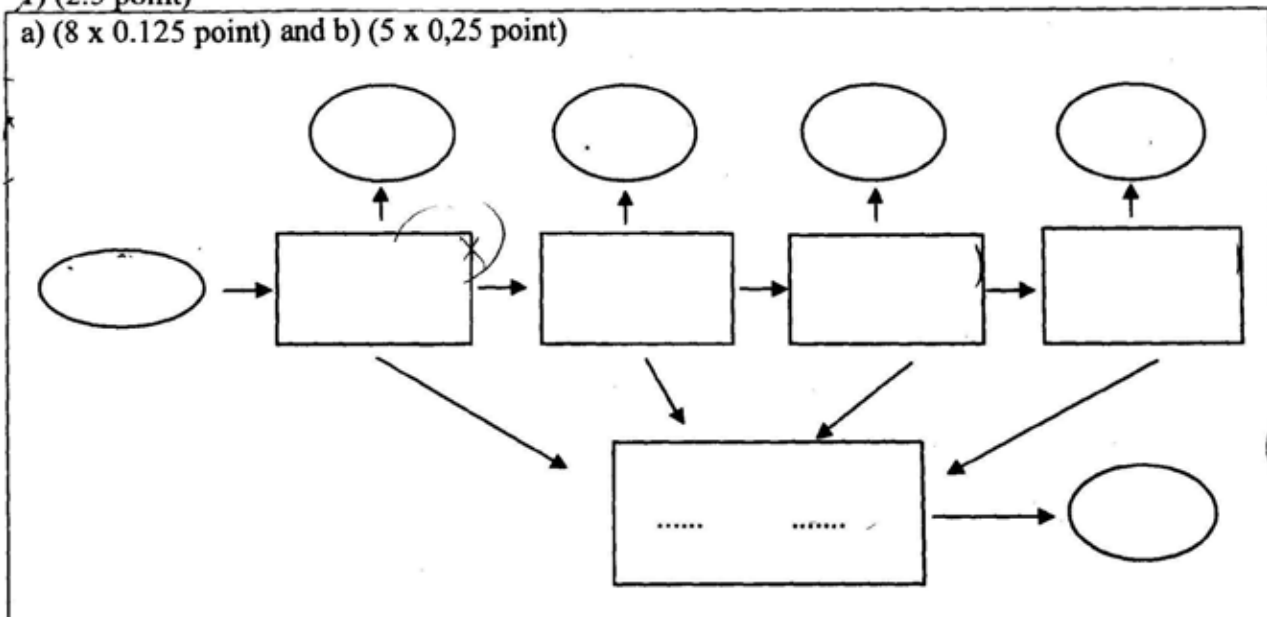
c) (1.0 point)

The photon has too low energy	
Not enough photons are produced	
The wavelength of each photon is too short	

Biology

1) (2.5 point)

a) (8 x 0.125 point) and b) (5 x 0.25 point)



c) (0.25 point)

2) (2.5 point)

a) (9 x 0.25 point)

	Type of nuclear (cell) division	Name of the stage shown	What will be separated in the next stage?
Figure A			
Figure B			
Figure C			

b) (0.25 point)

3) (2.5 point)

a) (1.0 point)

Types of twins	Figure A	Figure B
Monozygotic		
Dizygotic		
Trizygotic		

b) (1.0 point)

Options	Figure A	Figure B
Only same sex		
Only different sexes		
Maybe different sexes		



c) (0.5 point)

Placental functions	Correct	Incorrect
1. Transfers oxygen, nutrients and hormones from the mother to the foetus		
2. Helps in the digestion of mother's food.		
3. Protection of the foetus against most pathogens.		
4. Filters out waste from the foetus		

4) (2.5 point)

a) (1.0 point)

	Amoeba	Paramecium	Euglena	Trypanosoma	Spermatozoa	Oviduct Epithelial Cells
Cilia						
Flagella						
Pseudopodia						

b) (1.5 point)

	Amoeba	Paramecium	Euglena	Trypanosoma	Spermatozoa	Oviduct Epithelial Cells
I- only to cause movement of media surrounding the cell						
II- only to cause movement of the cell						
III- Both I and II						



Chemistry

1) (2.5 points)

a) (0.5 point)

b) (1.0 point)

c) (1.0 point)

2) (2.5 points)

a) (0.5 point)

b) (1.0 point)

c) (1.0 point)

A:

B





3) (2.5 points)

a) (0.5 point)

b) (2.0 points)

4) (2.5 points)