# TEST COMPETITION

December 5, 2006

## Read carefully the following instructions:

1. The time available is **2 hours and 30 minutes.**
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 choose your correct answer by crossing one of the capital letters in your answer sheet. There is only one right answer for each problem.

   *Example:*

| | | | | |
|---|---|---|---|---|
| 1 | ~~A~~ | B | C | D |

6. If you want to change your answer, you have to circle the first answer and then cross a new letter as your correct answer. You may only allow making one correction.

   *Example:*

| | | | | |
|---|---|---|---|---|
| 1 | (A) | B | C | ~~D~~ |

   A is the first answer and D is the corrected answer

7. 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.

8. **Point rules** :
   - **Correct answer : + 1.0 points**
   - **Wrong answer : – 0.25 points**
   - **No answer : 0.0 point**

# 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.

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.**

# TEST COMPETITION

**Ireland / United Kingdom**

**December 5, 2006**

**30 Points**

1. A particle moves along a straight line in such a way that its *displacement* during *any* given interval of 1 second is 3 meters larger than its displacement during the previous interval of 1 second. Which one of the following options is correct?

   A. The particle moves with constant acceleration of 3 m/s$^2$
   B. The particle moves with constant velocity of 3 m/s ✓
   C. The particle moves with constant velocity of 6 m/s
   D. The acceleration of the particle is increasing with time ✗

2. Despite the fact that the Earth-Sun distance is much larger than the Earth-Moon distance, the gravitational force exerted by the Sun on Earth is *larger* than the gravitational force exerted by the Moon o Earth. However, it is the Moon, and *not* the Sun, the main factor responsible for the high tides here on Earth. Why is that the case?

   A. Because of the revolution of the Moon around the Earth
   B. Because the mass of the Earth is more similar to the mass of the Moon
   C. Because the gravitational force the Moon exerts on Earth is more nonhomogeneous
   D. Because the angular diameter of the Moon, as seen from Earth, is smaller than that of the Sun ✓

3. A projectile is shot with velocity of 20 m/s in a direction which makes an angle of 15° with the vertical axis. At some point of its trajectory, the projectile splits in two identical pieces in such a way that the *internal* forces which caused the splitting only acted horizontally on each piece. By supposing that one piece fell 12 m far from the shooting point and that all trajectories are contained in the same plane, how far did the other piece fall from the shooting point? (Neglect the air resistance and adopt 10 m/s$^2$ as the local acceleration of gravity.) (Given that sine 15° = 0.26 and cos 15° = 0.97)

   A. 20 m or 60 m ✓
   B. 17 m or 53 m
   C. 25 m or 55 m
   D. 28 m or 52 m

4. On a sunny day, consider a scuba diver immersed in a wide swimming pool filled with water and whose walls and floor were painted in black. Looking upward, the diver sees the surface of water almost completely dark, except for an approximately circular region with radius $R$ above his/her head. If $n$ is the refractive index of water (relative to that of air) and $h$ is the depth of the eyes of the diver relative to the surface of water, the radius $R$ of the clear circular region is given by:

   A. $R = h\,(n^2-1)^{1/2}$
   B. $R = h\,(n^2+1)$
   C. $R = h\,/(n^2+1)$
   D. $R = h\,/(n^2-1)^{1/2}$

5. Consider a circular ring at a temperature $T_0$, with radius $R$, made from a material whose linear dilation coefficient is $\alpha$. There is a small gap in the ring, with width $d$ (see Figure 1). If we raise the temperature of the ring by an amount $\Delta T$ (small compared to $\alpha^{-1}$), what will happen to the gap?

   A. width will increase by an amount ($\alpha\, d\, \Delta T$)
   B. width will increase by an amount ($2\,\pi\, R\, \alpha\, \Delta T$)
   C. width will decrease by an amount [($2\,\pi\, R - d$) $\alpha\, \Delta T$]
   D. width will remain the same

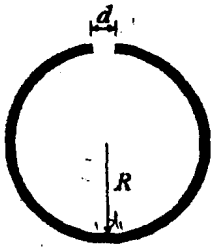


Figure 1

6. The minimum velocity necessary for a particle to escape the Earth's gravitational field, when thrown vertically up from Earth's surface, is approximately 11 km/s. Therefore, the necessary velocity for a particle to orbit the Earth close to its surface is approximately:
   A. 22 km/s
   B. 5 km/s
   C. 11 km/s
   D. 8 km/s

7. Watching the wheels of a moving car in a film, we usually get the impression that they are spinning slower than they really are (forward or backward), or even standing still. Suppose you are watching a film where the wheels of a moving car appear to be spinless. Considering that the wheels look like the one presented in Figure 2, with $R$ = 30 cm, what are, approximately, the possible velocities of the moving car? (Assume that the car's velocity is below 100 km/h and that it was filmed using 24 frames per second.)

   A. 24 km/h, 48 km/h, 72 km/h, 96 km/h
   B. 27 km/h, 54 km/h, 81 km/h
   C. 30 km/h, 60 km/h, 90 km/h
   D. 22 km/h, 44 km/h, 66 km/h, 88 km/h

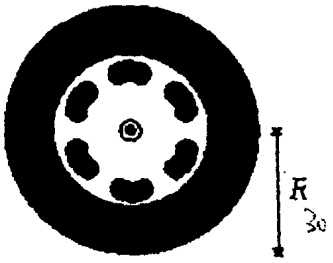


Figure 2

8. Consider a metallic disk spinning without friction around an axis passing through its center. A magnet is placed near the disk so that magnetic field lines cross some portion of the disk. What happens?

   A. Since the disk is electrically neutral, nothing happens and it continues spinning
   B. Due to the voltage generated, the disk accelerates
   C. Due to loss of energy through Joule effect, the disk decelerates and eventually stops
   D. The angular velocity of the disk oscillates, with kinetic energy being converted into magnetic energy, and vice-versa

9. A capacitor (with capacitance $C$) is connected to a resistor (with resistance $R$) which is immersed in a liquid whose specific heat coefficient we want to calculate. The mass of the liquid is $m$ and it is confined in a vessel with perfectly insulating walls (see Figure 3). Initially the voltage on the capacitor is $V$. After the switch $S$ turns the circuit on, the voltage on the capacitor eventually vanishes and the temperature of the liquid increases by $\Delta T$. Assuming that there were no losses and neglecting the heat capacity of the vessel, the specific heat coefficient of the liquid is given by: (Given that the energy of the capacitor is $W=q^2/2C$, where q is the initial charge of the capacitor)

   A. $CV^2/(2m\Delta T)$
   B. $V^2/(2mRC\Delta T)$
   C. $V^2/(Rm\Delta T)$
   D. $CV^2/(m\Delta T)$

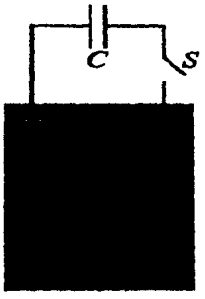


Figure 3

10. A person stands on the sidewalk when he/she hears the siren of an ambulance which approaches with velocity $V$. The ambulance passes in front of him/her and continues its way, getting farther and farther with the same velocity $V$. Let $f_1$ and $f_2$ be the frequencies of the siren heard by this person when the ambulance is approaching and when the ambulance is getting farther, respectively. If $f_0$ is the frequency of the siren as heard by the ambulance driver, which statement below is true?

A. $f_1 < f_2$ and $f_0$ is slightly larger than $(f_1 + f_2)/2$
B. $f_1 < f_2$ and $f_0$ is slightly smaller than $(f_1 + f_2)/2$
C. $f_1 > f_2$ and $f_0$ is slightly larger than $(f_1 + f_2)/2$
D. $f_1 > f_2$ and $f_0$ is slightly smaller than $(f_1 + f_2)/2$

11. Although the maintenance of life on Earth depends on all characteristics that define a living system, two characteristics are important in the preservation of life on the planet. These are:

(A) Complex chemical composition and colloidal state.
(B) High degree of organization and performance of vital functions.
(C) Maintenance of homeostasis and high degree of individuality.
(D) Reproductive capacity and heredity.

12. "The real wonder of DNA is its capacity to have small mistakes. Without this special attribute we would still be anaerobic bacteria, and the music would not exist (...).We say that *To err is human*, but the idea is not very agreeable, and it is even more difficult to accept the fact that errors are also biological" (adapted from: *Medusa and the Snail: More Notes of a Biology Watcher. by Lewis R. Thomas*, 1975). For living things this text refers to:

(A) Life Span.
(B) Reproduction.
(C) Excitability.
(D) Mutation

13. The scientific community has demonstrated the possibility of reproduction of animals using cloning technique. It consists of:

(A) Inject into a female ovum of a given species, a spermatozoid of a male of the same species.

(B) Extract and discard the nucleus of a female ovum of a given species and inject, into this enucleated ovum, the nucleus of a somatic cell from an individual of the same species.

(C) Inject, into the ovum of a female, the nucleus of another ovum of the same female.

(D) Extract and discard the nucleus of a somatic cell of a given species and inject, into this enucleated cell, the nucleus of an ovum cell of the same species.

14. The table below shows the blood test result of two patients. Analyze these data and mark the **INCORRECT** option.

| | John | Mary | Reference Values | |
|---|---|---|---|---|
| | | | Male | Female |
| Erythrocytes millions/mm$^3$ | 4.3 | 5.0 | 4.6 to6.2 | 4.2 to 5.7 |
| Leukocytes unit/mm$^3$ | 6500 | 13000 | 4500 to 10500 | |
| Platelets unit/mm$^3$ | 300 | 100 | 150 to 400 | |

(A) The result from Mary indicates a possible infection.
(B) Mary has difficulties in blood clotting.
(C) Mary has anaemia.
(D) John's diet may be lacking iron.

15. In general, plants have a much larger surface area/volume ratio. What is the main reason for this?

(A) The advantages of having a larger body surface in plants are correlated to the area of light absorption.

(B) Plants, in general, are bigger than animals.

(C) Animals need a larger volume in order to store water.

(D) Animals have more complex chemical substances in their bodies.

16. The organic pesticides were developed in the 1940s. Their effectiveness against crop diseases surprised everybody at the time. On the other hand, their high persistence in the environment resulted, after a period of time, in a large incidence of mortality of birds, which didn't come into direct contact with these products. This fact is related to the ecological concept of trophic magnification which means:

(A) Degeneration of the food chain.

(B) Accumulation of toxic residues in the large animals, because those consume larger quantities of food.

(C) Gradual increase in the concentration of the toxic products at every trophic stage in the food chain.

(D) A larger resistance of the animals of lower trophic levels to the toxicity of those products in relation to animals in upper trophic levels.

17. Water plays an important role in biology. Indicate the option that presents the correct statement about this liquid.

(A) The metabolic activity of a cell is directly related to its hydration condition.

(B) Water living beings obtain oxygen needed for their respiration from water molecules.

(C) The terrestrial living beings do not depend on water for their reproduction, respiration and metabolism.

(D) Water dissolves only cellular molecules, but does not participate in the cellular metabolic activities.

18. The majority of the energy used in the planet today is produced by burning fossil fuels. The Kyoto protocol, an international agreement that includes the decrease in the emission of $CO_2$ and other gases, demonstrate the present preoccupation with the environment. The excess of fossil fuel burning can have as consequences:

(A) Increase in acid rains and increase in the ozone layer.

(B) Increase in the greenhouse effect and the level of the oceans.

(C) Global temperature decrease and increase in the levels of oceans.

(D) Destruction of the ozone layer and decrease of the greenhouse effect.

19. One of the problems in the use of solar energy as an alternative energy source is the difficulty in storing that energy. Some group of living beings developed the capacity of storing that energy in organic compounds to use in their metabolic processes. The process of storing this energy and example of groups that can perform it are, respectively:

| | Process | Groups of living beings |
|---|---|---|
| (A) | Fermentation | Plants and bacteria |
| (B) | Chemosynthesis | Plants and molds |
| (C) | Photosynthesis | Photosynthetic Bacteria and molds |
| (D) | Photosynthesis | Cyanobacteria and green plants |

20. A black woman gave birth to twins. One was black and the other white. Both parents of the twins are descendants of mixed couples (black and white). The genetic explanation of the twins is:

(A) Two spermatozoan fertilized two eggs, forming embryos that developed independently and simultaneously in the uterus.

(B) Only one spermatozoan fertilized one ovum that divided forming monozygotic twins.

(C) Two spermatozoan fertilized only one ovum, forming two embryos that developed independently in the uterus.

(D) Two spermatozoan fertilized only one ovum, forming two embryos that generated dizygotic twins.

21. Phenolphthalein of pH range [8-10] is used in which of the following type of titration as a suitable indicator:

a) $NH_4OH$ and HCl
b) $NH_4OH$ and HCOOH
c) $NH_4OH$ and $CH_3COOH$
d) NaOH and $CH_3COOH$

22. The removal of two hydrogen atoms from a primary alcohol produces what type of chemical substance?

a) Ketone
b) Hydrocarbon
c) Aldehyde
d) Ether

23. Which of the following elements would form an acid oxide with the formula $XO_2$ and an acidic compound with hydrogen with the formula $H_2X$?

a) Sodium
b) Magnesium
c) Aluminum
d) Sulphur

24. Solids may be considered to be either crystalline or noncrystalline. The basic difference between them is that a crystal, in contrast to a noncrystal:

a) has a lower density
b) has an irregular array of atoms
c) exhibits double refraction
d) has a completely regular atomic or molecular structure

25. When vinegar and baking soda are mixed together, the gas formed is:

a) oxygen
b) nitrogen
c) carbon dioxide
d) hydrogen

26. What is the name given to the equation PV=nRT?

a) law of partial pressure
b) ideal gas equation
c) quadratic equation
d) Raoult's equation

27. You have a solution of 0.50 molar Sodium Phosphate and need to prepare a solution of 50 millimolar Sodium Phosphate. How much water would you add to 100 milliliter of the original 0.50 molar solution to produce the 50 millimolar solution?

a) 90 milliliters
b) 450 milliliters
c) 100 milliliters
d) 900 milliliters

28. Pure water is approximately at what molar concentration:

a) 0.55 Molar
b) 5.5 Molar
c) 55 Molar
d) 550 Molar

29. - The structure of an ammonia molecule ($NH_3$) can be best described as:

a) linear
b) tetrahedral
c) pyramidal
d) trigonal planar

30. List the following atoms in order of increasing electron affinity: oxygen, boron, and fluorine.

A-/ D

a) boron, oxygen, fluorine
b) oxygen, boron, fluorine
c) fluorine, boron, oxygen
d) fluorine, oxygen, boron