11th International Junior Science Olympiad

Multiple Choice Questions

December, 4 2014

EXAMINATION RULES

1. No competitors are allowed to bring any tools except his/her personal medicine or any personal medical equipment

2. Each competitor has to sit according to his/her designated desk.

3. Before the examination starts, each competitor has to check the stationary and any tools (pen, ruler, calculator) provided by the organizer.

4. Each competitor has to check the Question and Answer Sheets. Raise your hand, if you find any missing sheets. Start after the bell rings.

5. During the examination, competitors are not allowed to leave the examination room, except in case of emergency. In such case, the examination supervisor will accompany them.

6. You are not to disturb other competitors. If you need any assistance you may raise your hand and wait for a supervisor to come and assist you.

7. There will be no questions or discussions about the examination questions. The competitors must stay at their desks until the time allocated for the examination is over, even if they have finished the examination earlier and do not wish to continue working.

8. 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 at this time. All competitors must leave the room quietly. The Question and Answer Sheets must be put neatly on your desk.

READ CAREFULLY THE FOLLOWING INSTRUCTIONS:

1. The time available is 3 hours.
2. The total number of questions is 30. Check that you have a complete set of the test questions and Answer Sheet.
3. Use only pen provided (not pencil).
4. Write down your name, code, country and signature in your Answer Sheet.
5. Read carefully each question and choose your correct answer by crossing one of the lowercase letters in your Answer Sheet. There is only one correct answer for each question.
6. Additional sheets are provided for rough work.

Example:

1	~~a~~	b	c	d

7. 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 are allowed to make only one correction.

Example:

1	(~~a~~)	b	c	~~d~~

A is the first answer and D is the corrected answer

8. Competitors are not allowed to bring any tools from outside. After completing your answers, all the Question and Answer Sheets should be put neatly on your desk.
9. Point rules:

   Correct answer: +1.0 point
   Wrong answer: -0.25 point
   No answer : 0.0 point

TEST COMPETITION

The Aconcagua Mountain has the highest elevation in the Southern Hemisphere. It belongs to the frontal range formation of the Andes and is located in the Central-West of Argentina, in Mendoza province. It is the highest mountain in America. It has two main peaks, one of 6 962 m a.s.l. (meters above sea level); and the other, the Southern peak, of 6 930 m a.s.l. Several glaciers are located on its hillsides, the most important ones being the Northeast or Polish Glacier, and the Eastern or English Glacier.

Reaching the Aconcagua peak is a challenge that calls for climbers worldwide.

Figure 1

1. The temperature of the human organism, considering deep tissues, is around 37ºC, which is subject to slight variations according to the time of day, physical activity, environmental temperature and certain metabolic processes.

Various neural feedback mechanisms can regulate body temperature. Some mechanisms are:

1. Tremblings caused by increased muscle tone.
2. Evaporation of water from the skin and mucous membranes.
3. Increased basal metabolism and thyroxine blood level.
4. Panting and peripheral vasodilation.
5. Peripheral vasoconstriction.

When a man faces a sharp drop in temperature as it happens at the Aconcagua summit, compensatory mechanisms that tend to maintain body temperature are:

a. 1, 2 and 4
b. 2, 3 and 4
c. 1, 3 and 5
d. 2, 3 and 5

2. *The skin is the interface between the internal and external environments, and the exchanges of energy that affect body temperature. These exchanges between the body and the environment are the result of mechanisms such as radiation, conduction, and convection.*

In a low temperature environment (as the one at the Aconcagua summit) the amount of energy lost through convection by a person without insulating clothing, will be proportional to:

a. The surface area of their body, and the difference in temperature between his body and the environment
b. The fourth power of their body temperature
c. Only the difference in temperature between their body and the environment
d. The person's height and the difference in temperature between their body and the environment

3. The atmospheric pressure at sea level is called normal pressure. The concentration of oxygen (O_2) under these conditions is 20.9 %v/v, so that the partial pressure of oxygen (pO_2) is 21.2 kPa. For the human body this concentration is sufficient to saturate the hemoglobin in blood. As one climbs the Aconcagua, the atmospheric pressure decreases, while the fraction of O_2 and all other gases remain constant.

Figure 2 represents the percentage change of atmospheric pressure as a function of altitude.

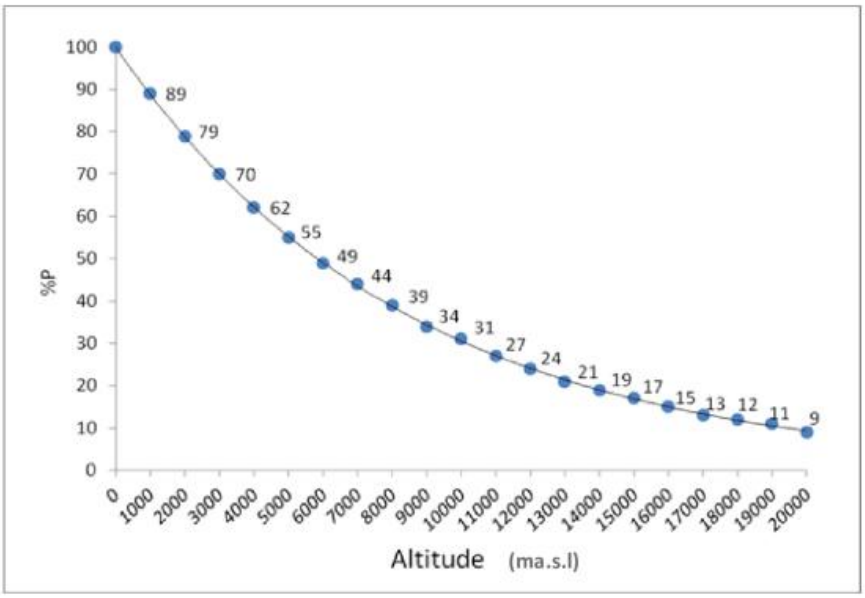


Figure 2

Knowing that Mount Aconcagua has a maximum altitude of 6 962 m a.s.l. (consider 7000 m), the pO_2 at the summit will be:

a. 44.00 kPa

b. 9.33 kPa

c. 21.00 kPa

d. 0.44 kPa

4. The curve shown in Figure 2 is the graph of:

a. A quadratic function

b. An exponential function

c. A linear function

d. A trigonometric function

5. The slope value of the tangent to the curve at the point with coordinates (3 000 m a.s.l.; 70 %) in Figure 2 is:

   a. Null

   b. Positive

   c. Negative

   d. Cannot be determined

6. *A climber is training to participate in an expedition to the summit of Aconcagua. For this reason, he goes to an area of high altitude to acclimatize and avoid acute mountain sickness, caused by air pressure reduction and consequently a low partial oxygen pressure (pO_2).*

   One of the acclimation mechanisms is:

   a. Pulmonary hyperventilation by venous chemoreceptors stimulation.
   b. Increase in number of erythrocytes.
   c. Decreased supply of oxygen to the muscles.
   d. Decreased oxygen diffusion by increased capillary surface.

7. Figure 3 shows the arterial oxygen saturation as a function of altitude when breathing air or pure oxygen. According to this, in the ascent to Mount Aconcagua, at 4 500 m a.s.l. , breathing air implies a saturation of hemoglobin with oxygen of approximately:

   a. 100%
   b. 92%
   c. 82%
   d. 72%

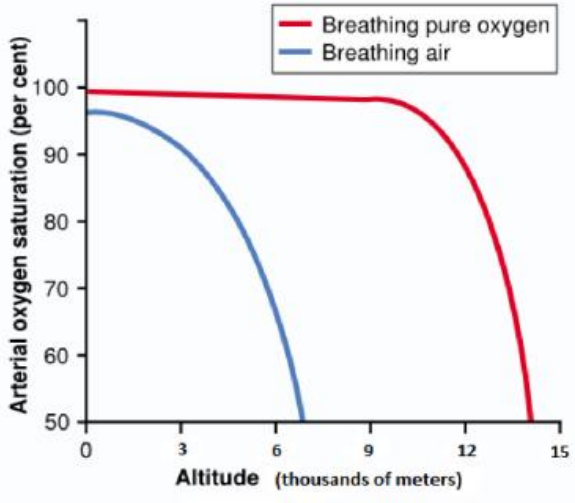


Figure 3

8. The differences in the chemical composition of the extracellular and intracellular fluids are vitally important for cells. The components of these liquids are almost equal; however, concentrations vary between both of them.
Mark the <u>incorrect</u> option taking into consideration the chemical composition of the intra- and extracellular fluids, transport mechanisms and the organs responsible for regulating the internal environment.

   a. Blood plasma and other extracellular fluids have similar ionic composition but vary in their protein content.
   b. Calcium ion (Ca^{2+}) is almost exclusively present in extracellular fluid. However, it is of vital importance within muscle cells.
   c. Extracellular fluid contains higher concentrations of chloride (Cl^-), potassium (K^+), hydrogen carbonate [$(HCO_3)^-$] ions than intracellular fluid.
   d. Metabolic products are eliminated mainly through the lungs and kidneys.

9. Assume the dissociation of a diatomic molecule, $Y_2(g) \rightleftarrows 2\ Y(g)$ is an endothermic reaction. Figure 4.1 schematically shows the equilibrium state of dissociation and Figure 4.2 schematically shows the equilibrium state after a change.

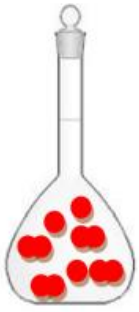


Figure 4.1

Figure 4.2

The introduced change that leads to equilibrium shown in Figure 4.2 is:

   a. The addition of Y atoms
   b. A decrease in temperature
   c. A decrease in volume
   d. An increase in temperature

Echo is an acoustic phenomenon produced when a sound wave is reflected and returns to its source. In the case of human hearing, in order for the echo to be perceived it is necessary for it to overcome acoustic persistence: required minimum time difference between the perception of two sounds by the ear, so that the human brain can distinguish them as different. In the case of dry sounds (like words) the acoustic persistence is 70.0 ms.

10. A climber, as shown in Figure 5, is standing at wall A and shouts toward wall B. The two walls can be considered perfectly vertical and flat. Considering that the speed of sound in air at that height is 344 ms^{-1}, the minimum distance from the wall that he must be at in order to hear the first echo is:

a. 24.1 m
b. 12.0 m
c. 241 m
d. 4.9 m

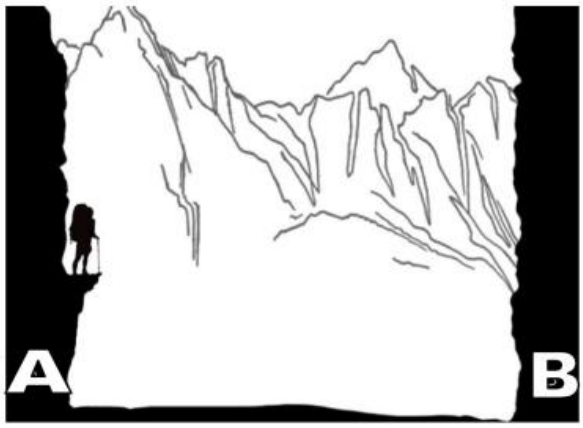


Figure 5

*11. The energy transported by a wave per unit time and per unit area through a surface perpendicular to the propagation direction is called intensity. If the waves propagate equally in all directions from a source of power P, the intensity **I** at a distance **r** is therefore* $\boldsymbol{I = \frac{P}{4\pi r^2}}$

Knowing that the distance between wall A and wall B is r, the intensity with which the climber hears the second echo, compared to the intensity with which he hears the first echo (I_0), will be (disregard energy loss in wall B reflection, and any interference effect):

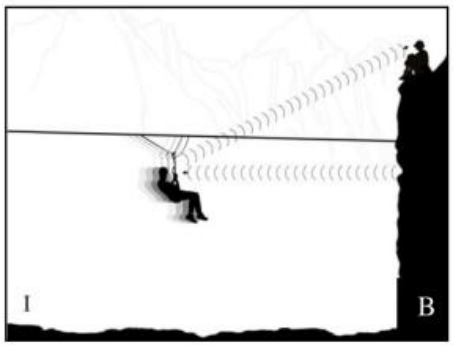
a. $I_0/4$
b. $I_0/2$
c. I_0
d. $2I_0$

The climber finds an old Tyrolean traverse (taut wire that connects the two sides of the mountain canyon) and decides to cross over. During his journey, on which he moves with constant velocity towards and perpendicular to wall B, the climber blows his whistle continuously. The pictures below are just a schematic representation of the situation.

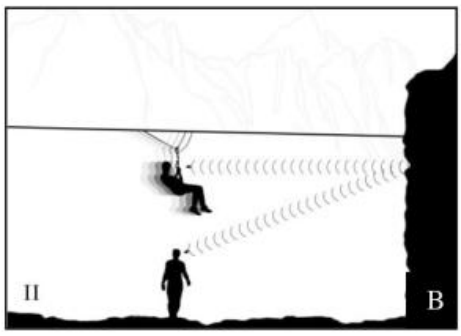
12. Taking into account the Doppler effect and neglecting the effect of wall A, select the correct option:

The frequency of the wave coming from wall B is perceived by the climber to be:

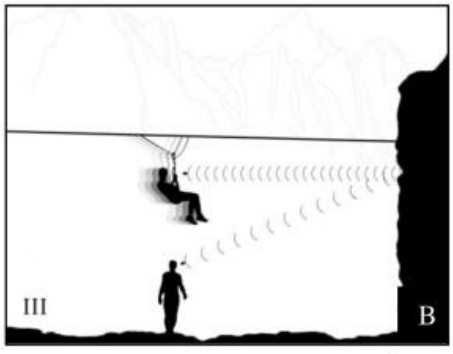
a. Equal to the frequency emitted by the whistle in motion that a person at rest sitting on the wall B, would receive



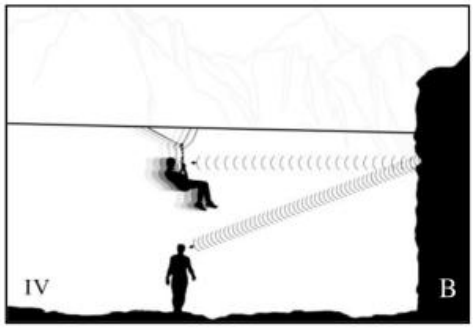
b. Equal to the frequency that a person at rest located at the same distance as the climber, would perceive coming from the wave reflected from wall B



c. Higher than the frequency that a person at rest located at the same distance as the climber, would perceive coming from the wave reflected from wall B



d. Lower than the frequency that a person at rest located at the same distance as the climber, would perceive coming from the wave reflected from wall B



13. Adult human hemoglobin (HbA) consists of four polypeptide chains, two α with 141 amino acids and two β with 146 amino acids.

The amino acid sequence of the polypeptide chain is known as:

a. The quaternary structure of hemoglobin
b. The tertiary structure of hemoglobin
c. The primary structure of hemoglobin
d. The secondary structure of hemoglobin

14. Hemoglobin may become abnormal by a mutation in the β chain of the normal protein thereby forming insoluble superpolymers that precipitate and generate sickle-shaped erythrocytes (Figure 7).

The synthesis of abnormal hemoglobin type "S" (Hb S) is governed by a recessive allele. Two parents are heterozygous for sickle-shaped erythrocytes. The percentage chance of genotypes in their offspring is:

Figure 7

a. 50% heterozygous and 50% recessive homozygous
b. 50% heterozygous and 50% dominant homozygous
c. 25% dominant homozygous, 25% recessive homozygous, 50 % heterozygous
d. 25% dominant homozygous, 50% recessive homozygous, 25% heterozyg

15. People who are homozygous for HbS suffer from falciform anemie disease /sickle cell anemia. What can be deduced from the altered hemoglobin and the abnormal shape of the erythrocyte?

a. Oxygen transport to tissues is canceled
b. Blood flow is reduced because of abnormal erythrocytes blocking blood vessels
c. Oxygen transport is not altered
d. Blood flow in vessels is decreased by precipitation of hemoglobin/HbS

16. Precipitation of red blood cells causes blockages in the blood vessels preventing normal tissue nutrition. The cross sectional area of an arteriole can be reduced up to 1/5 of the normal value.

When the cross sectional area of the arteriole is reduced, the velocity through this reduced section will be:

a. Higher than in the surrounding area where the cross sectional arteriole area is greater
b. Equal to the velocity in the surrounding area where the cross sectional arteriole area is greater
c. Lower than in the surrounding area where the cross sectional arteriole area is greater
d. Unchanged

17. Hemoglobin is composed of four pyrrole groups bound to Fe^{2+} (ferrous ion).

Fe (iron) is a transition metal, with atomic number 26 and mass number 56.

The ion of Fe (iron) above mentioned, will have:

a. 26 protons, 26 electrons and 30 neutrons
b. 26 protons, 24 electrons and 30 neutrons
c. 26 protons, 24 electrons and 24 neutrons
d. 26 protons, 26 electrons and 32 neutrons

18. Given the following standard reduction potentials for the redox pairs chemical species:

Chemical species	Standard Reduction Potential: Eº (V)
Fe^{2+} / Fe	-0.44
Cu^{2+} / Cu	+0.34
Zn^{2+} / Zn	-0.76
Ag^{+} / Ag	+0.80

It is possible to state that, in standard conditions, when arranging these species in pairs in an electrochemical cell:

a. Fe^{2+}(aq) is reduced when paired with all other elements (Cu(s), Zn(s) and Ag(s))
b. Fe^{2+}(aq) is an oxidizing agent when paired to Ag(s) and Cu(s), and Fe(s) a reducing agent when paired with Zn^{2+}(aq)
c. Fe(s) is oxidized when paired wih Ag^{1+}(aq), Cu^{2+}(aq), and Fe^{2+}(aq) is reduced when paired with Zn(s)
d. Fe(s) is oxidized only when paired with Zn^{2+}(aq)

19. In Mendoza flora, Atriplex lampa are an angiosperm with imperfect (unisexual) flowers.

These flowers are on separate plants, so in this case we are referring to a plant type:

a. Monoecious with flowers with stamens and carpels together
b. Monoecious with staminate flowers and carpellate flowers
c. Dioecious with staminate flowers and carpellate flowers
d. Dioecious with flowers with stamens and carpels together

20. *Osmosis modifies cells shape. If Atriplex lampa leaves are placed in a media with high salt concentration with respect to the plant, the solution is of the type:*

a. Hypotonic, causing movement of water to the outside of cells, the leaf wilts
b. Hypertonic, causing movement of water to the outside of the cell, the leaf wilts
c. Hypertonic, causing movement of water into the cell increasing turgor pressure
d. Hypotonic, causing movement of water into the cell, increasing turgor pressure

21. Regarding the formation of images by thin optical lenses, it is correct to ascertain that:

a. If the lens is divergent, as an object approaches the focal point from far away, the formed image is real, inverted, and more distant
b. If the lens is convergent, as an object approaches the focal point from far away, the formed image is real, upright, and more distant
c. If the lens is divergent, as an object approaches the focal point from the center of the lens, the formed image is real, upright, and smaller than the object
d. If the lens is convergent, as an object approaches the focal point from the center of the lens, the formed image is virtual, upright, and bigger than the object

22. *Different structures in animals allow maintenance of salt and water balance and excretion of metabolic waste. The functions of a species' excretory organs, and the composition of its excretions, both depend on the environment they inhabit.*

In the following table, column A presents different taxa belonging to the Animal Kingdom. Column B shows some excretory structures.

Select the right option which indicates the correlation between the number in column A and the letter in column B:

Column A		Column B	
1	Mammalia (Vertebrata)	A	No excretory organs
2	Gastropoda (Mollusca)	B	Kidneys
3	Hexapoda (Arthropoda)	C	Malpighian tubules
4	Asteroidea (Echinodermata)	D	Nephridia

a. 1-A; 2-B; 3-C; 4-D
b. 1-B; 2-D; 3-C; 4-A
c. 1-B; 2-A; 3-D; 4-C
d. 1-C; 2-B; 3-D; 4-A

23. The chemical element **A** has atomic number 11 and the chemical element **B**, 17. The electronic configuration of these elements in the ground state is :

a. A: $1s^2\ 2s^2\ 3s^3\ 3p^4$ B: $1s^2\ 2s^2\ 3s^2\ 2p^6\ 3p^6$
b. A: $1s^2\ 2s^2\ 2p^6\ 3s^1$ B: $1s^2\ 2s^2\ 3s^2\ 3p^5$
c. A: $1s^2\ 2s^2\ 3s^3\ 3p^4$ B: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$
d. A: $1s^2\ 2s^2\ 2p^6\ 3s^1$ B: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$

24. If the pressure of an ideal gas is halved and the absolute temperature of the gas is doubled, the volume of the gas:

a. Will increase by four times its original value
b. Will decrease to one fourth of its original value
c. Will stay the same as its original value
d. Will increase by two times its original value

25. 1.0 mole of CO_2 is placed in a sealed container with 1.0 mole of water at 25ºC. Then, half of the water from the container is siphoned out while the temperature is kept constant. The concentration of CO_2 gas dissolved in the remaining water inside the container:

a. will decrease because the amount of water in the container evaporates easily
b. will decrease because the volume of CO_2 gas will increase and so will its pressure
c. will decrease because the smaller amount of water decreases the solubility CO_2
d. will decrease because its pressure decreases and so does its solubility

26. A yellow-brown crystalline substance is heated strongly in a test tube at 280ºC. A clear liquid condenses around the mouth of the tube and the crystals gradually lose their yellow color and become dark green powder. Every gram of yellow-brown crystalline substance produces 0.39 g of clear liquid and 0.61 g of dark green powder. The same weight relationships are observed for samples of the crystals taken from many different sources.
These observations are consistent with the hypothesis that the yellow-brown crystalline substance is:

a. A Solution
b. A heterogeneous mixture
c. A hydrated salt
d. An element

27. Water is a compound with anomalous physical properties, giving it particular characteristics that allow the existence of life. These properties can be explained by stating that:

a. Water molecules can interact amongst themselves through hydrogen bonds
b. Water molecules make ionic bonds between oxygen-hydrogen giving water solubility to other compounds and forming solutions
c. Water molecules show only London forces
d. Water molecules show very weak interactions amongst themselves, and this is the reason of their easy ionization

28. Consider an experiment in which a particle moves in two dimensions on a table. The particle goes from point P1 to point P2 with constant speed along four different paths (Figure 8), but the time it takes to go from P1 to P2 is the same for all of them. Suppose now that the physicist carrying out the experiment measures the kinetic energy of the particle at point X in each trajectory. Select the path for which the kinetic energy at point X has the minimum value:

a. A
b. B
c. C
d. D

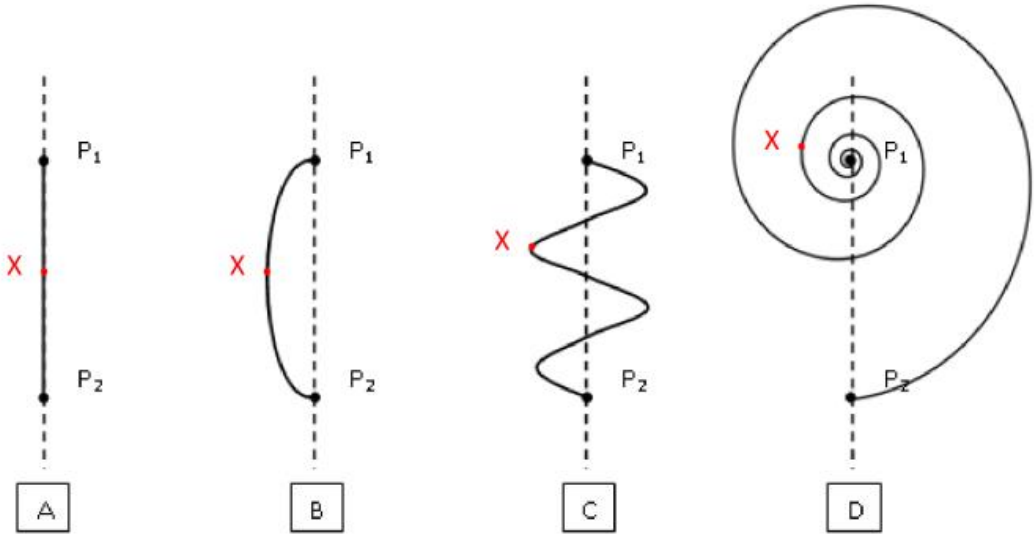


Figure 8

29. *Ozone in the stratosphere is formed under the effect of solar radiation on oxygen molecules. The total volume of ozone in the atmosphere is equivalent to a layer that under conditions of 25 ° C temperature and 1 bar pressure, would cover the Earth with a thickness of 3 mm. Its presence in the stratosphere is vital to maintaining life on Earth.*

Ozone is an:

a. Oxygen isotope
b. Oxygen ion
c. Oxygen allotrope
d. Oxygen isomer

30. Consider the circuit shown in Figure 9. If the resistance of each edge of the cube is R, the resistance between points a and h is:

a. 12R
b. (5/6)R
c. R
d. (3/2)R

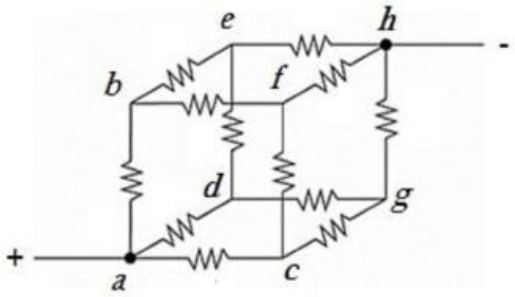


Figure 9

11th International Junior Science Olympiad

Multiple Choice Questions

December, 4 2014

CODIGO:

NOMBRE	
APELLIDO	
CÓDIGO:	
PAÍS	
FIRMA:	

Nº	RESPUESTA			
1	a	b	c	d
2	a	b	c	d
3	a	b	c	d
4	a	b	c	d
5	a	b	c	d
6	a	b	c	d
7	a	b	c	d
8	a	b	c	d
9	a	b	c	d
10	a	b	c	d
11	a	b	c	d
12	a	b	c	d
13	a	b	c	d
14	a	b	c	d
15	a	b	c	d

Nº	RESPUESTA			
16	a	b	c	d
17	a	b	c	d
18	a	b	c	d
19	a	b	c	d
20	a	b	c	d
21	a	b	c	d
22	a	b	c	d
23	a	b	c	d
24	a	b	c	d
25	a	b	c	d
26	a	b	c	d
27	a	b	c	d
28	a	b	c	d
29	a	b	c	d
30	a	b	c	d