7TH INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

Abuja, Nigeria

December 2-11, 2010

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, ruler, 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 rings.
6. 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.
7. 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.
8. 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.
9. 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.

MULTIPLE CHOICE EXAMINATION
December 4, 2010
Abuja, Nigeria

Read the following instructions carefully:

1. The time available is 3 hours.
2. The total number of the questions is 30. Check that you have a complete set of the test questions and the answer sheet.
3. Use only the pen provided.
4. Write down your name, code, 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 are only allowed to make 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. Grading rules**:**

- Correct answer : + 1.00 point
- Wrong answer : : - 0.25 point
- No answer : 0 point

MULTIPLE CHOICE EXAMINATION QUESTIONS

Information for Questions 1 & 2

Mr. Jimoh Bello was 17 years old when he had a deep cut on his left leg and bled excessively without blood clot. Under normal conditions, when a tissue is wounded blood flows from it, and coagulates to form a blood clot. The clot then prevents further blood loss and entry of pathogenic microorganisms and the process of clotting depends on some clotting factors working in harmony with each other. Further investigation showed that Jimoh's blood would not clot. The conditions in which individual's blood does not clot is usually seen only in males and it is an inheritable gene mutation transmitted on an X chromosome and it is recessive to the normal allele. Jimoh's father's mother is not a carrier of the recessive gene for bleeding. Use the above information to answer questions 1 and 2.

1. The above information shows that,

   I. Mr. Jimoh's mother definitely has the ability for blood clotting.

   II. Jimoh's mother was a carrier of the gene that predisposes one to excessive blood loss.

   III. Mr. Jimoh's father had the gene that predisposes one to excessive blood loss.

Which of the above statements is/ are correct?

A. I only

B. II and III

C. III only

D. I and II

2. If Jimoh marries a normal woman that is not a carrier of the abnormal allele, what is the probability that they will give birth to a son that will produce excessive bleeding?

A. ¾

B. ½

C. ¼

D. 0

3. It is often possible to measure the amount of air normally present in the respiratory system and the rate at which ventilation occurs. The maximum amount of air that can be forcibly inhaled and exhaled from the lungs is called the vital capacity. The amount of air normally inhaled and exhaled with each breath is called the tidal volume. The residual volume is the air that always remains in the lungs after maximum forced exhalation, preventing the alveoli from collapsing. The expiratory reserve volume is the volume of air that can still be forcibly exhaled following a normal exhalation.

   The total lung capacity will be equal to,

   A. Tidal volume plus expiratory reserve volume

   B. Vital capacity plus expiratory reserve volume

   C. Vital capacity plus residual volume

   D. Residual volume plus expiratory reserve volume.

4. Which of these is true of mountain dwellers in relation to people residing at sea level?

   A. Mountain dwellers have greater vital capacity and enlarged thoracic cavity

   B. Mountain dwellers have reduced vital capacity and compressed thoracic cavity

   C. Mountain dwellers inhale a smaller amount of air than people living at sea level

   D. Mountain dwellers have a reduced concentration of red blood cells compared to people living at sea level.

5. As an adaptive mechanism desert animals must conserve water by all means. The kidneys regulate the concentration of salt and water in the blood through the formation and excretion of urine. The kidney is composed of approximately one million units called nephrons. The kidneys of desert animals have modified nephrons which help them survive long periods without water. Which of these options best describes the expected modification?

   A. A short collecting duct

   B. A very long loop of Henle

   C. A very short distal tubule

D. A large Bowman's capsule

Use the diagram below (Figure 1) to answer questions 6-7

The amount of DNA present per cell at different stages during several nuclear divisions is represented in Figure 1.

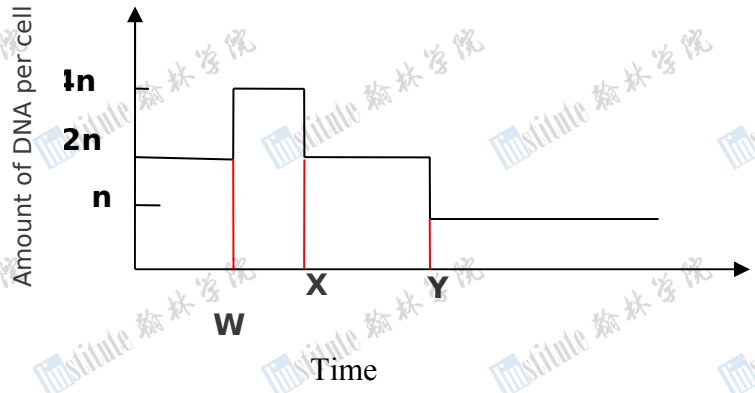

Figure 1: Variations in DNA content of cell

6. What type of nuclear division is represented by Figure 1 above ?

A. Mitosis

B. Meiosis

C. Cytokinesis

D. None of the above.

7. What stages are represented by the lines W, X, Y?

A. Interphase , telophase I, telophase II.

B. Interphase , prophase, telophase II

C. Prophase , Interphase, telophaseI

D. Interphase, anaphase, telophase I

8. The knowledge of the age structure of populations is important in the understanding of population dynamics because of the relevance of age to the reproductive role of organisms, including humans. A convenient way to picture age distribution in a population is to arrange the data in a form of polygon or age pyramid as shown below. Which pyramid in Figure 2 indicates a near stationary population?

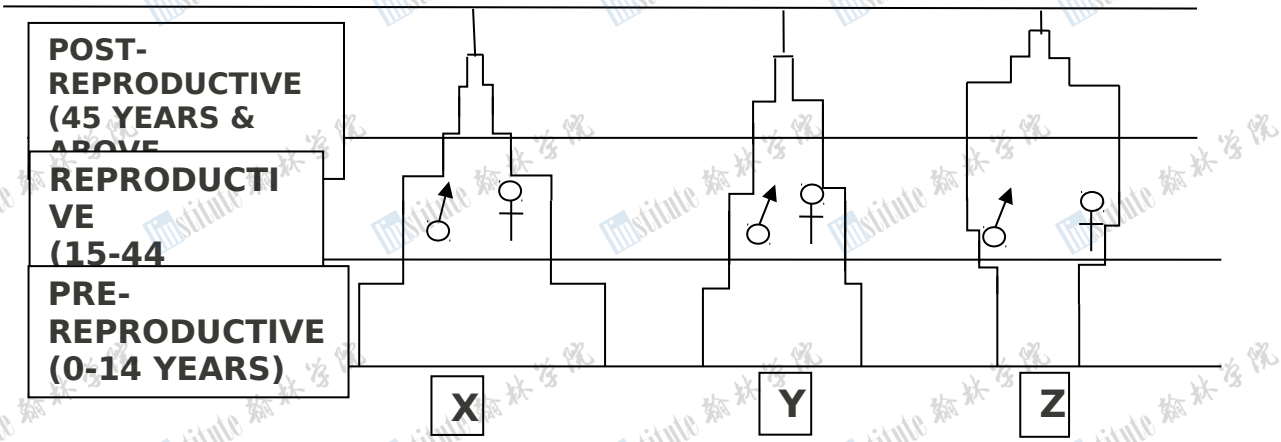

Figure 2: Age pyramid

A. X
B. Y
C. Z
D. None of the above

9. For any animal to survive in water, it must devise a means of obtaining oxygen for respiration. Fishes, for instance, obtain oxygen dissolved in water through their gills. Which of the following way(s) is (are) correct as sources of oxygen for aquatic insects?

i. Atmosphere
ii. Oxygen dissolved in water
iii. Air-containing cavities of submerged aquatic plants

A. iii
B. i, ii
C. i, ii, iii
D. ii, iii

10. Certain environmental conditions such as availability of water, optimum temperature and oxygen, must be present before the embryo of a seed will grow. Sometimes light is required for the seed to germinate. Seeds which require a stimulus of light for germination are usually relatively small. Which of following best explains the significance of this?

A. Small seeds commonly require light before germination will occur.

B. Small seeds commonly require light to inactivate the growth inhibitors in its coat before germination.

C. Small seeds have relatively small food reserves; it is therefore important that growing shoot reaches light quickly so that photosynthesis can start before the reserves are exhausted.

D. Small seeds commonly require light to find a suitable place for germination.

11. Colloidal systems can be described in terms of the dispersed phase and dispersion phase as

a. Liquid – gas
b. Liquid – liquid
c. Liquid – solid
d. Solid – liquid

Examples of the systems (a) – (d) above include:

I. Shampoo
II. Gelatin
III. Fog
IV. Paint

Which of the following is the correct match?

A. a – I, b – II, c – III, d – IV
B. a – II, b –I, c – IV, d – III
C. a – IV, b –III, c – II, d – I
D. a – III, b – I, c – II, d – IV

12. A zinc metal sample containing zinc chloride as impurity was made to react with an excess of dilute hydrochloric acid at 27°C. Liberated hydrogen gas is collected at 760 mm Hg pressure that occupies 780.0 cm^3 volume. If the vapour pressure of water at 27°C is 14 mm Hg, what is the volume of H_2 at STP? The Standard pressure is 760 mm Hg (molar volume of gas at standard temperature and pressure, STP = 22.4 dm^3)

A. 746 cm^3
B. 697 cm^3
C. 750 cm^3
D. 300 cm^3

13. A compound containing carbon 53.10%, hydrogen 15.95% and nitrogen was found to have a molecular weight of 90 g/mol (C = 12 g/mol; H = 1g/mol; N= 14 g/mol). The molecular formula is

A. $C_4 H_{14} N_2$
B. $C_2 H_7 N$
C. $C_3 H_{12} N_2$
D. $C_2 H_{14} N_2$

Use Figure 3 to answer Question 14:

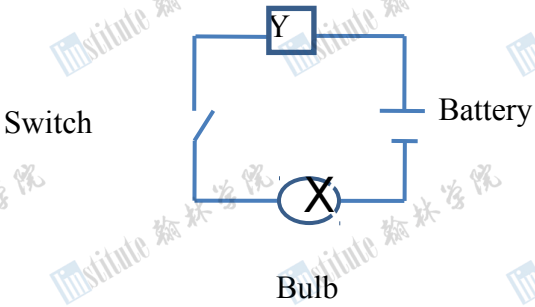

Figure 3: Electric circuit

14. When the switch is closed, the bulb in the set up above will light if:

A. Y is section of an orange fruit
B. Y is a section of dried avocado pear
C. Y is distilled water
D. Y is a beaker of 95% ethanol

15. For the oxidation–reduction reaction;

$K_2Cr_2O_7 + XH_2SO_4 + YSO_2 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + ZH_2O$

The values X, Y and Z are:

A. 1, 3,1
B. 4,1,4
C. 3,2, 3
D. 2,1,2

16. Biochemists have discovered more than 400 mutant varieties of haemoglobin, the blood protein that carries oxygen throughout the body. A physician studying a variety of haemoglobin associated with a fatal heart disease first finds its molar mass (M). She dissolves 21.5 mg of the protein in water at 5.0°C to make 1.50 cm^3 of solution and measures

an osmotic pressure of 0.00475 atm. What is the molar mass of this haemoglobin variety? [R = 0.0821 *l*- atm mol^{-1} K^{-1}]. Osmotic pressure (π) = CRT

A. 6.89×10^4 g mol^{-1}

B. 7.89×10^4 g mol^{-1}

C. 8.88×10^4 g mol^{-1}

D. 6.47×10^4 g mol^{-1}

17. The table below shows the pH ranges of some common indicators:

Indicator	**pH Range**
Methyl Violet	−0.3-1.8
Methyl Orange	2.8-3.8
Congo Red	2.8-4.8
Methyl Red	3.8-6.1
Bromothymol Blue	6.0-7.9
Phenol Red	6.8-8.6

Given that K_a is 7.3×10^{-10} for boric acid (H_3BO_3), choose an indicator that can be used for the titration of 0.10 M KH_2BO_3 with 0.10 M HCl?

A. Methyl orange
B. Congo Red
C. Methyl Red
D. Phenol Red

18. A gas X at 1atm is bubbled through a solution containing a mixture of 1M Y^- and 1M Z^- at 25°C. If the order in the electrochemical series is $Z > Y > X$ then
    A. Y^- will oxidize X and not Z^-
    B. Y^- will oxidize Z^- and not X
    C. Y^- will oxidize both X and Z^-
    D. Y^- will reduce both X and Z^-
19. The air entering the lungs passes through tiny sacs called alveoli, from which oxygen diffuses into the blood. The average radius of the alveoli is 0.0050 cm, and the air inside contains 14 mole percent oxygen. Assuming that the pressure in the alveoli is 1.0 atm and the temperature is 37°C; calculate the number of oxygen molecules in one of the alveoli (R = 0.08206 *l*- atm mol^{-1} K^{-1}; 6.023×10^{23} molecules $mole^{-1}$)
    A. 1.7×10^{11} oxygen molecules
    B. 1.7×10^{13} oxygen molecules
    C. 1.7×10^{12} oxygen molecules

D. 1.7×10^{10} oxygen molecules

20. Metabolism is the stepwise breakdown of the food we eat to provide energy for growth and function. A general overall equation for this complex process represents the degradation of glucose ($C_6H_{12}O_6$) to CO_2 and H_2O. This metabolic process involves many steps and its enthalpy (ΔH) is called the enthalpy of combustion. This is because the same quantity of heat is evolved whether we burn 1 mole of glucose in air or let the metabolic process break it down. Which of the following equations can be used to calculate the standard enthalpy of the metabolic process correctly?

A. $\Delta H^o = [\Delta_f H^o (CO_2) + \Delta_f H^o (H_2O)] - [\Delta_f H^o (C_6H_{12}O_6) + \Delta_f H^o (O_2)]$
B. $\Delta H^o = [3\Delta_f H^o (CO_2) + 3\Delta_f H^o (H_2O)] - [\Delta_f H^o (C_6H_{12}O_6) + 3\Delta_f H^o (O_2)]$
C. $\Delta H^o = [3\Delta_f H^o (CO_2) + 6\Delta_f H^o (H_2O)] - [\Delta_f H^o (C_6H_{12}O_6) + 3\Delta_f H^o (O_2)]$
D. $\Delta H^o = [6\Delta_f H^o (CO_2) + 6\Delta_f H^o (H_2O)] - [\Delta_f H^o (C_6H_{12}O_6) + 6\Delta_f H^o (O_2)]$

21. Given that the universal gravitational constant, $G = 6.7 \times 10^{-11}\ Nm^2\ kg^{-2}$ and that the mass, M of the earth is 6.0×10^{24} kg, find the speed of a satellite that is fixed to permanently focus on the city of Abuja for broadcast of the 2010 IJSO competition.
A. $3.08 \times 10^3\ ms^{-1}$
B. $24\ ms^{-1}$
C. $40\ ms^{-1}$
D. $3.66 \times 10^3\ ms^{-1}$

22. The surfaces of a biconvex lens have radii of curvature of 0.10m and 0.15m. Given that $1/f = (n-1)\ [1/r_1 + 1/r_2]$ and the refractive index of the glass is 1.5, find the power of the lens, correct to two significant figures:

A. -8.3D
B. -1.7D
C. 1.7D
D. 8.3D

23. The Doppler principle refers to a difference in frequency observed due to the relative motion of the observer and the moving source. Speed limit violators are usually monitored by the use of a radar gun which releases microwaves on the moving vehicle in short bursts. By applying the Doppler principle, the difference (Δf) between the frequency of the microwave emitted by the radar gun and that reflected by the moving vehicle (and received by the gun) is obtained. The velocity (v) of the vehicle is then determined. If Δf is 2667 Hz and the frequency of the microwave is 1.0×10^{10} Hz, obtain the speed of the car.

A. 160 ms^{-1}

B. 80 ms^{-1}

C. 40 ms^{-1}

D. 27 ms^{-1}

24. Solar radiation reaches the earth's atmosphere at a rate of 1353 Wm^{-2}. If 36% of this radiation is reflected back into space and 18% is absorbed by the earth's atmosphere. The radiant emittance is given by σT^4 where σ is the Stefan-Boltzmann's constant and T is the absolute temperature. What maximum temperature would an isolated black body on the earth's surface be expected to attain? ($\sigma = 5.67 \times 10^{-8}$ $Wm^{-2}K^{-4}$).

A. 120°C
B. 63.9°C
C. 50.7°C
D. 31.4°C

25. A body of mass, m, resting on a smooth inclined plane at an angle θ to the horizontal is connected to a mass M over a smooth pulley (Figure 4). Find the velocity, v of the object of mass m when it has moved a distance b up the plane.

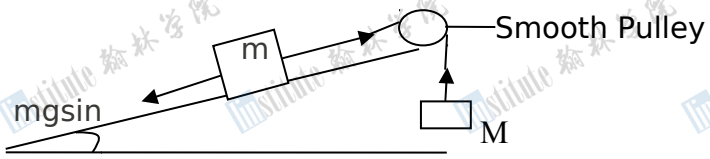

Figure 4 : Inclined Plane

A. $v = \sqrt{\frac{2gb(M-msin\theta)}{M+m}}$

B. $v = \sqrt{\frac{gb\ (M+msin\theta)}{M+m}}$

C. $v = \sqrt{\frac{2gb\,(m-msin\theta)}{M-m}}$

D. $v = \sqrt{\frac{gb(M-msin\theta)}{M-m}}$

26. In using an axe to split firewood, the following energy forms are involved

(i) Chemical (muscle) energy
(ii) Mechanical potential energy of the axe;
(iii) Chemical (binding) energy of wood, heat energy, sound energy and kinetic energy of wood fragments;
(iv) Mechanical kinetic energy of the axe.

Which is the most likely sequence of the energy exchanges?

A. (i), (ii), (iv), (iii)
B. (i), (iv), (iii), (ii)
C. (iv), (i), (ii), (iii)
D. (i), (ii), (iii), (iv)

27. A jet of water travelling at a velocity of $20ms^{-1}$ hits a wall normally. Calculate the pressure on the wall if the water does not bounce back. (Density of water (ρ) = $1.0 \times 10^3 kgm^{-3}$).

A. 8.0×10^5 Pa
B. 4.0×10^5 Pa
C. 2.0×10^5 Pa
D. 2.0×10^{-4} Pa

28. The rate of heat conduction is proportional to the cross-sectional area and temperature gradient (temperature difference per unit length). On a typical day during the World Cup tournament in South Africa, the air in a room is heated to 25°C while the air outside is -2°C. The area of the window of the room is 2 m^2 and it is made of crown glass with thickness 2 mm and thermal conductivity 1.0 $WK^{-1}m^{-1}$. What is the heat power loss through the window?

A. 1.2 kW
B. 2.7 kW
C. 27 kW
D. 50 kW

29. The ratio of radii of two planets P and Q is x and the ratio of their mean densities is y. Find the ratio of the acceleration of free fall on P to that on Q in terms of x and y.

A. $\frac{x}{y}$
B. x^2y
C. x + y
D. xy

30. Two point charges, q and Q, are separated as shown in the Figure 5. Determine the electric potential difference between points X and Y.

NB: $1/4\pi\varepsilon_0 = 9.0 \times 10^9\ Nm^2C^{-2}$; potential at a point distance, r from a charge, q is given by $V = \frac{q}{4\pi\varepsilon_0 r}$

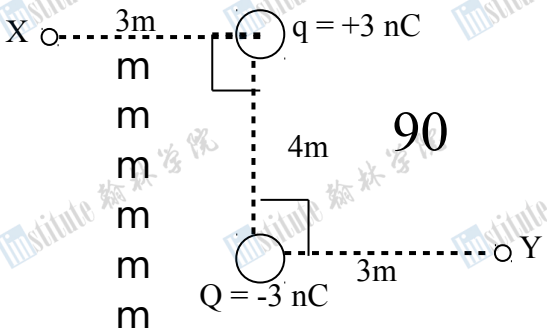

Figure 5: Point Charge Distribution

A. 8.4 V
B. 7.2 V
C. 6.0 V
D. 0.0 V