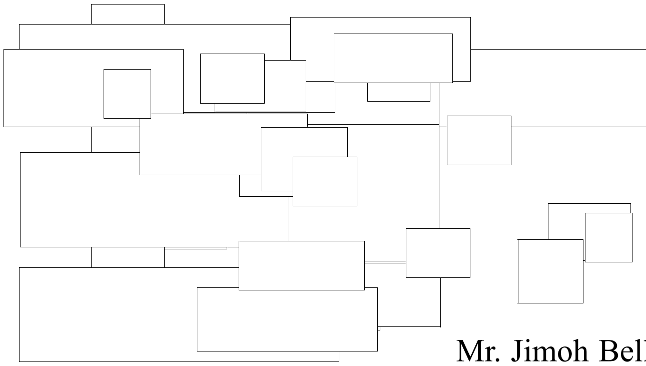

# SOLUTIONS FOR MULTIPLE CHOICE QUESTIONS

**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. 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

**Solution**

Excessive blood loss (Haemophilia) is a sex-linked disorder which affects only males. Recessive genes that are carried on the X chromosome will produce the recessive phenotypes whenever they occur in males, since no dominant allele is present to mask them.

**Answer: D**

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

**Solution**

| | X | X |
|---|---|---|
| $X^c$ | $X^cX$ | $X^cX$ |
| Y | XY | XY |

None of the sons will produce excessive bleeding.

**Answer: D**

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, 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.

**Solution**

Total lung capacity is the vital capacity, which is the maximum of air that can be inhaled or exhaled forcibly plus the residual volume, the air that always remains in the lungs preventing the alveoli from collapsing.

**Answer: C**

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 havea reduced concentration of red blood cells than people living at sea level.

**Solution**

Mountain dwellers would be expected to have the greater vital capacity. The partial pressure of $O_2$ in the upper atmosphere is much lower than it is at sea level. So mountain dwellers generally have to inhale a greater volume of air than people living at sea level to extract the same amount of oxygen. Mountain dwellers generally have an enlarged thoracic cavity so that they can inhale and exhale a greater volume of air per breath.

**Answer: A**

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

**Solution**

The loop of Henle concentrates sodium in the surrounding interstitial cells to establish a solute gradient for reabsorption of water. The longer the loop of Henle, the greater the distance the filtrate must travel through this gradient and with a greater distance; more water must be reabsorbed and conserved.

**Answer: B**

The amount of DNA present per cell at different stages during several nuclear divisions is represented inFigure 1. Use the diagram below (Figure 1) to answer questions 6-7

Figure1: Variations in DNA content of cell

**n**

**4n**

**2n**

Amount of DNA per cell

**Z**

**W**

**X**

**Y**

Time

6. What type of nuclear division is represented by Figure1?

A. Mitosis

B. Meiosis

C. Cytokinesis

D. None of the above.

**Solution**
The figure represents reduction division (2n – n) i.e. meiosis.
**Answer: B**

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

A. Interphase , telophase I, telophase II.

B. Interphase , prophase, telophase II

C. Prophase , Interphase, telophaseI

D. Interphase, anaphase, telophase I

**Solution**

Interphase – Replication of cell organelles; most of the DNA is replicated in Interphase.

Telophase I – Reduction of chromosome number occurs.

Telophase II – Nucleus now possesses half the number of single chromosomes of the original parent cell (haploid).

**Answer: A**

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?

**POST-REPRODUCTIVE**

**(45 YEARS & ABOVE**

**REPRODUCTIVE**

**(15-44 YEARS)**

**PRE-REPRODUCTIVE**

**(0-14 YEARS)**

X Y Z

**Fig 2: Age pyramid**

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

**Solution**

There is a near balance between pre-reproductive, reproductive and post-reproductive age groups.

**Answer B**

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.

**Answer C**

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.

**Solution**

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.

**Answer: C**

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

a. Liquid – gas

b. Liquid – liquid

c. Liquid – solid

d. Solid – liquid

Examples of the systems (A) – (D) above include

I. Milk

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

**Solution**

An example of a liquid in gas colloidal system = fog, liquid in liquid = milk, liquid in solid = gelatine, solid in liquid = paint

**Answer: D**

12. Zinc of mass, 2.5 g containing zinc chloride as impurity was made to react with an excess of

dilute hydrochloric acid at 27ºC and 760 mm Hg, liberating 780.0 $cm^3$ of hydrogen. If the vapour pressure of water at 27ºC is 14 mm Hg, what is the volume of $H_2$collected at STP? (Zn = 65.0; H = 1.0; Cl = 35.5; molar volume of gas at STP = 22.4 $dm^3$)

A. 746 $cm^3$

B. 697 $cm^3$

C. 750 $cm^3$

D. 300 $cm^3$

**Solution**

$Zn + 2HCl \quad ZnCl_2 + H_2$

, therefore= 760 - = 746 mmHg

Let the volume of $H_2$ at STP = $V_2$. Given that $P_1$ = 746 mmHg, $V_1$ = 780 $cm^3$, $T_1$ = 273 + 27 = 300K, $P_2$ = 760 mmHg, $T_2$ = 273K, $V_2$ = ?

Using the expression, =

**Answer: B**

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. $C_2 H_{14} N_2$

**Answer: A**

Use Figure 3 to answer Question 14:

Battery

Switch

X

Fruit

**Figure 3: Electric circuit**

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

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

**Solution**

Orange fruit contains citric acid which ionises to produce $H^+$, avocado pear is dry and so no ionisation can take place, distilled water does not contain ions.

**Answer A**

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

**Solution**

From the reaction, $Cr_2O_7^-$ is reduced to $Cr^{3+}$ and $SO_2$ is oxidized to $SO_4^{2-}$

$Cr_2O_7^- + 14H^+ + 6e^- \rightarrow Cr^{3+} + 7H_2O$ (Reduction) (i)

$3SO_2 + 6H_2O \rightarrow 3SO_4^{2-} + 12H+ + 6e^-$ (Oxidation) (ii)

Addition of (i) and (ii) gives

$Cr_2O_7^- + 2H^+ + 3SO_2 \rightarrow 3SO_4^{2-} + 2Cr^{3+} + H_2O$

$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow 3K_2SO_4 + Cr_2(SO_4)_3 + H_2O$

Hence X = 1, Y = 3 and Z = 1

**Answer: A = 1, 3, 1**

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 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 $mol^{-1}$ $K^{-1}$]

A. $6.89 \times 10^4$ g $mol^{-1}$

B. $6.79 \times 10^4$ g $mol^{-1}$

C. $6.88 \times 10^4$ g $mol^{-1}$

D. $6.87 \times 10^4$ g $mol^{-1}$

**Solution**

Combining unit conversion steps and solving for molarity:

$\pi = CRT$

$\pi$ = 0.00475 atm; T = 273+5.0 = 278 K; V = 0.00150 L

$C = \pi/RT = 0.00475/ (0.0821\ l\ \text{atm mol}^{-1}\ K^{-1})\ (278K) = 2.08 \times 10^{-4}$ M

Finding the amount (mol) of solute:

Moles of solute = C x V = $(2.08 \times 10^{-4}\ \text{mol}/l)\ (0.00150l) = 3.12 \times 10^{-7}$ mol

Calculating molar mass of haemoglobin (after changing mg to g):

M= 0.0215g3.12×10-7mol =6.89× 104g/mol

**Answer: A**

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 |
| Bromothylmol Blue | 6.0-7.9 |
| Phenol Red | 6.8-8.6 |

Given that $k_a$ is 7.3 x $10^{-10}$ for $KH_2BO_3$, choose an indicator that can be used for the titration of 0.1 M $KH_2BO_3$ with 0.10 M HCl?

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

**Solution**

$KH_2BO_3 + HCl \rightarrow H_3BO_3 + KCl$

At equivalent point the concentration of $H_3BO_3$ produced = 0.050 M. $H_3BO_3$ then ionizes thus;

$H_3BO_3 + H_2O \rightarrow \quad H_3BO_3^- + H_3O^+$

0.05 M $\qquad x \qquad x$

$k_a = [H_3O^+][\ H_3BO_3^-]/[\ H_3BO_3] = x^2/0.05$

i.e., 7.3 x $10^{-10} = x^2/0.05$

$x = 6.04 \times 10^{-6}$

pH = -log (6.04 x$10^{-6}$) = 5.22

This pH is in the range of methyl red indicator which will be suitable for the titration

**Answer: C**

18. A gas X at 1atm is bubbled through a solution containing a mixture of 1 M $Y^-$ and 1 M $Z^-$ at 25$^O$C. If the reduction potentials are in the order 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

**Solution**

In redox reaction substances with:

(i) higher $E^o$ values will oxidize those with lower $E^o$ values
(ii) lower $E^o$ values will reduce those with higher $E^o$ values.

On the basis:

Y has higher $E^o$ value than X; Y will oxidize X
Y has lower $E^o$ value than Z; Y will not oxidize Z
Y has lower $E^o$ value than Z ; Y will reduce Z
Y has higher $E^o$ value than X; Y will not reduce X

**Answer: A**

19. The air entering the lungs passes up in 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 $37^{O}C$; calculate the number of oxygen molecules in one of the alveoli (R = 0.08206 l- atm $mol^{-}$ $K^{-}$)

A. $1.7 \times 10^{11}$ oxygen molecules
B. $1.7 \times 10^{13}$ oxygen molecules
C. $1.7 \times 10^{12}$ oxygen molecules
D. $1.7 \times 10^{10}$ oxygen molecules

**Solution**

Radius, r = 0.0050 cm
T = 273+37 = 310 K
The volume of one alveolus = $V = (4/3)\pi r^3$
$= (4/3)3.12\ (0.0050cm)^3$
$= 5.2 \times 10^{-7}\ cm^3$
But $1L = 10^3\ cm^3$
Hence $V = 5.2 \times 10^{-7} \times 10^{-3}\ L = 5.2 \times 10^{-10}L$
No of moles, n of air in one alveolus can be calculated from PV = nRT
n = PV/RT
$= (1.0\ atm \times 5.2 \times 10^{-10}L)/\ (0.08206\ L\ atm\ mol^{-}\ K^{-} \times 310K)$
$= 2.0 \times 10^{-11}$ mol
1 mol of oxygen = $6.022 \times 10^{23}$ molecules
$2.0 \times 10^{-10}$ mol of oxygen = $2.0 \times 10^{-11} \times 6.022 \times 10^{23}$ molecules
$= 12.044 \times 10^{12}$ molecules

Air inside the alveolus is 14% oxygen,
Therefore no of oxygen molecules = $(14/100) \times 12.044 \times 10^{12}$
$= 1.69 \times 10^{12}$ oxygen molecules

**Answer: C**

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 ($\Delta H$) 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) $\Delta H^o = [6\Delta_f H^o\ (CO_2) + 6\Delta_f H^o\ (H_2O)] - [\Delta_f H^o (C_6H_{12}O_6) + 6\ \Delta_f H^o\ (O_2)]$

**Solution**

$\Delta H^o = [6\Delta_f H^o\ (CO_2) + 6\Delta_f H^o\ (H_2O)] - [\Delta_f H^o\ (C_6H_{12}O_6) + 6\ \Delta_f H^o\ (O_2)]$

**Answer: D**

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 $6.0 \times 10^{24}$ 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. $3.66 \times 10^3\ ms^{-1}$

**Solution**

Centripetal force = gravitational force ⇒, mv2r=GmMr2 , from where v2=GMr
where v is the velocity. Period, T=2πrv giving r=Tv2π

Hence v3=2πGMT With $T = 24\ hr = 8.64 \times 10^4$ s

v=32π×6.7 ×10-11×6.0×10248.64×104 = $3.08 \times 10^3$ ms

**Answer: A**

22. The surfaces of a biconvex lens have radii of curvature of 0.10m and 0.15m. If the refractive index of the glass is 1.5, the power of the lens, correct to two significant figures, is

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

**Solution**

Use n = 1.5; r=0.10m; r= 0.15m
get $f$ = 0.12m
Power, P =

**Answer: D**

23. 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 ($\Delta$f) 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 $\Delta$f is 2667 Hz and the frequency of the microwave is 1.0 x $10^{10}$ Hz, obtain the speed of the car.

A. 160 $ms^{-1}$

B. 80 $ms^{-1}$

C. 40 $ms^{-1}$

D. 27 $ms^{-1}$

**Solution**

$\Delta$f = 2vfc where c is the speed of light ;

Hence

= 3.0 x 108 x 26672 x 1.0 x 1010 = 40 ms

**Answer: C**

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, what maximum temperature would a black body on the earth's surface be expected to attain when left by itself? (Stefan-Boltzmann's constant = 5.67 x$10^{-8}$ $Wm^{-2}K^{-4}$).

A. 120 $^oC$
B. 63.9$^oC$
C. 50.7$^oC$
D. 31.4$^oC$

**Solution**

Of the solar radiation reaching the earth's atmosphere

36% is reflected back into space

18% is absorbed by the earth's atmosphere

This implies that only 46% reaches the earth's surface

If absorbed by a black body, expect that the maximum temperature of this body is given by

where $I_{sc}$ = 1353 $Wm^{-2}$

**Answer: 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 (Fig. Q5). Find the velocity, v of the object of mass m when it has moved a distance b up the plane.

θ

m

mgsinθ

Smooth Pulley

M

A. $v= 2gbM-m\sin\theta M+m$
B. $v= Gb\ (M+m\sin\theta)M+m$

C. $v= 2gb(m-m\sin\theta)M-m$
D. $v= gb(M-m\sin\theta)M-m$

**Solution**

Decrease in PE of system = Mgb – mgbsinθ

Increase in KE of system = $12\ (M+m)v2$

**Answer: A**

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)

**Answer: A**

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 ($\rho$) = $1.0 \times 10^3 kgm^{-3}$).

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

**Answer: B**

28. On a typical day during the World Cup tournament in South Africa, the air in a room is heated to 25°C while the outside air 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 power loss through the window?

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

**Solution**

**Answer: C**

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. xy

B. x2y

C. x + y

D. xy

**Solution**

Density of any planet, $\rho = 3g4\pi Gr$

$\rho p = 3gp4\pi Grp$ ; $\rho Q = 3gQ4\pi GrQ$

$\rho p\rho Q = gpgQrQrp$; $gpgQ = \rho p\rho QrprQ = xy$

where $x = rprQ$ and $y = \rho p\rho Q$

**Answer: D**

30. Two point charges, q and Q, are separated as shown in the FQ10. Determine the electric potential difference between points X and Y.

3m

4m

Y

q = +3nC

Q = -3nC

X

3m

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

**Solution**

4m

3m

3m

5m

X

Y

Q=-3nC

q=-3nC

rqX=3m  rqY=5m

rQX=5mrQY=3m

; where = 9 x $10^9$mF$^{-1}$

$V_X - V_Y = 7.2V$

**Answer: B**