INTERNATIONAL JUNIOR SCIENCE OLYMPIAD
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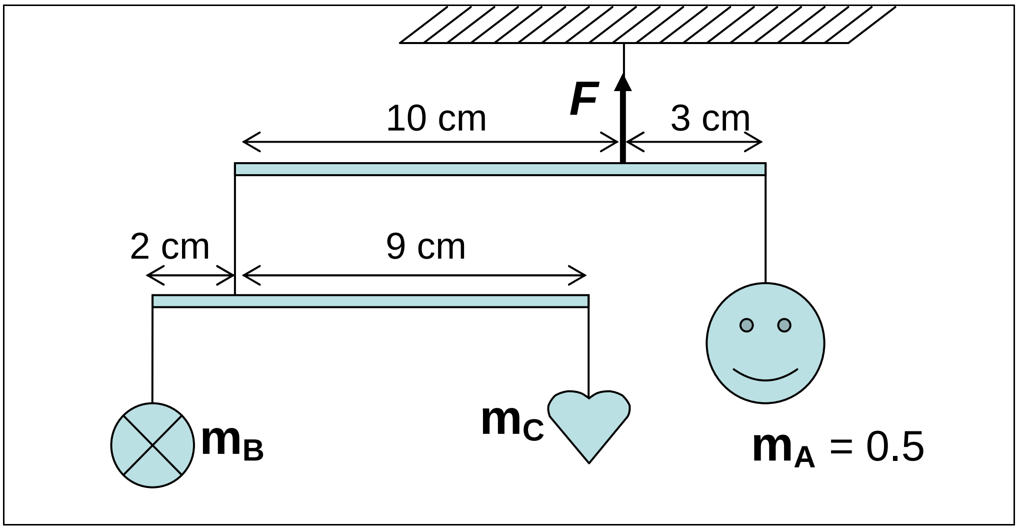
Solutions for TEST COMPETITION

1. The mobile system in the Figure is in the equilibrium condition. The object of m_A has a mass of 0.5 kg and hang at the first crossbar. The second crossbar supports the mass of m_B and m_C. Determine the tension F at the first crossbar and the masses of the objects m_B and m_C by neglecting the weights of crossbars. ($g = 9.8\ m/s^2$).



A. $F = 6.37$ N, $m_B = 0.12$ kg, $m_C = 0.03$ kg

B. $F = 5.37$ N, $m_B = 0.12$ kg, $m_C = 0.03$ kg

C. $F = 6.37$ N, $m_B = 0.10$ kg, $m_C = 0.03$ kg

D. $F = 6.37$ N, $m_B = 0.12$ kg, $m_C = 0.01$ kg

Answer: A

Solution

Look at the sub-system at the upper crossbar, and consider the center of rotation at the F.

$$\sum \tau = 0$$

$$0 = -0.03 \times 0.5\ kg \times 9.8\ m/s^2 + 0.1 F_{CB}$$

$$F_{Bc} = \frac{0.03 \times 0.5 \cdot 9.8}{0.1} = 1{,}47\ N$$

Look at the sub-system of $m_B m_C$, and consider the center of rotation at the edge of m_B.

$$\sum \tau = 0$$

$$= 0.02 \cdot F_{BC} - 0.11 \cdot F_C$$

$$F_c = \frac{0.02 \cdot F_{BC}}{0.11} = \frac{0.02 \times 1.47\ N}{0.11}$$

$$= 0{,}267\ N$$

$$m_C = \frac{F_C}{g} = \frac{0.267\ N}{9.8\ m/s^2}$$

$$m_C = 0.03\ kg$$

Again look at the sub-system of $m_B m_C$, and consider the center of rotation at the edge of m_C.

$$\sum \tau = 0$$

$$= -0.09 \cdot F_{BC} + 0.11 \cdot F_B$$

$$F_B = \frac{0.09 \cdot F_{BC}}{0.11} = \frac{0.09\ m \times 1.47\ N}{0.11\ m} = 1.2 N$$

$$m_B = \frac{1{,}2\ N}{9.8\ m/s^2} = 0.12\ kg$$

Therefore: $F = F_A + F_{BC} = (0.5 \times 9{,}8 + 1{,}47) N = 6.37\ N$

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2. Two identical twin babies are born from one mother. The babies are the result of the fertilization of:

A. One ovum with two sperms

B. Two ovums with one sperm

C. One ovum with one sperm

D. Two ovums with two sperms

<u>Answer: C</u>

→ The principle of fertilization: one ovum is fertilized by one sperm. So the answer of (A) & (B) are wrong. The answer of D probably is true but it cannot be accepted since the mother only delivers two identical babies one to each other.

3. The voltage in household wiring (220 volt) is used for lighting of a 100 W-bulb. The resistance R of the tungsten at 20 ^oC is 89.5 Ω. If the temperature coefficient of tungsten α = 0.0045 $^oC^{-1}$, estimate the temperature of the tungsten used as a wire resistance in the bulb.

A. 1120 ^oC
B. 1020 ^oC
C. 1000 ^oC
D. 980 ^oC

Answer: C

Solution

I = P/V = 100 W/ 220V = 0.4545 A, R(t) = V/I = 484.05 Ω,
$R(t) = Ro [1 + \alpha (T - T_o)] = 89.5\ \Omega\ [1 + 0.0045\ ^oC^{-1} (T-20)\ ^oC]$
T = 1000 ^oC
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4. Select the statement that is **not** an appropriate method for separating and purifying substances:

A. Petroleum is separated from crude oil by fractional distillation
B. The mixture of various compounds could be separated by chromatography
C. Sodium Chloride is separated from the seawater by extraction
D. Iodine contained in sand mixture is separated by sublimation

Answer : **C**

Sodium Chloride in seawater cannot be separated by extraction but crystallization.
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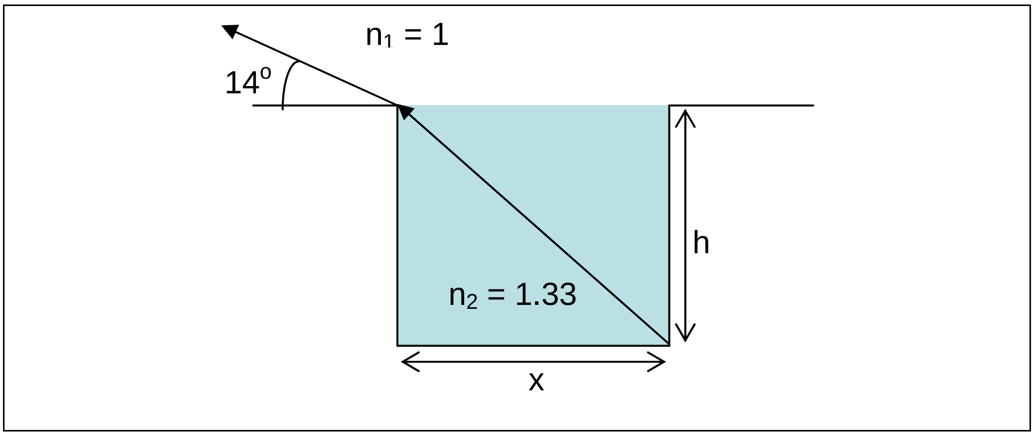
5. A student sees the top and the bottom edges of a pool simultaneously at an angle of 14^o above the horizontal as shown in the Figure.



What is the new view angle, if he wants to see the top edge and the bottom center of the pool (n = index of refraction, $n_{water} = n_2 = 1.33$ and $n_{air} = n_1 = 1$)?

A. 28.4^o
B. 38.0^o
C. 46.8^o
D. 51.3^o

Answer: D

Solution

In order to see the bottom edge of the pool

$n_1 \sin(90^o - 14^o) = n_2 \sin\theta$

$\sin 76^o = 1.33 \sin\theta \rightarrow \theta = 46.85$

$\tan\theta = 1.07$

In order to see the bottom center of the pool

$$\sin(90^o - \theta_2) = n2 \cdot \frac{\frac{1}{2}x}{(\frac{1}{4}x^2 + h^2)} = n2 \cdot \sin((\tan^{-1} \tfrac{1}{2}\tan\theta))$$

$$= 1.33 \sin(\tan^{-1} 1.07/2)$$

$$= 0.626$$

$\theta_2 = 90^o - \sin^{-1}[0.626] = 51.3^o$

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6. The mechanisms of antibiotics are to inhibit the following processes, **<u>except</u>**:

A. nucleic acid synthesis

B. protein synthesis

C. capsule synthesis

D. cell wall synthesis

Answer: C

The target of antibiotic in the body or cell of organism are: the cell wall, the membrane cell, protein synthesis and nucleic acid synthesis

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7. Several indicators are used to determine the pH of river water sample. If an indicator was added to the sample, the color of indicators added to the water sample is shown below:

Indicator added	**Color of indicator in water sample**
Methyl orange	yellow
Methyl red	yellow
Bromthymol blue	blue
Phenolphthalein	colorless

Table: pH range of indicators used:

Indicator	**Range of pH**	**Changes in color**
Methyl orange	3.1 – 4.4	red to yellow
Methyl red	4.2 – 6.2	red to yellow
Bromthymol blue	6.0 – 7.6	yellow to blue
Phenolphthalein	8.3 – 9.6	colorless to red

By using pH range of above indicators, the pH range of the river water is:

A. $3.1 < pH < 7.0$

B. $4.4 < pH < 7.6$

C. $6.0 < pH < 8.3$

D. $7.6 < pH < 8.3$

Answer: D

Treatment the sample with indicators gives results:

- Methyl orange changes color to be yellow indicates that pH > 4.4
- Methyl red changes color to be yellow, indicates that pH > 6.2
- Bromthymol blue changes color to be blue, indicates that pH > 7.6
- Phenolphthalein changes color to be colorless, indicates that pH < 8.3

Therefore the pH range of the sample is $7.6 < pH < 8.3$

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8. Choose the **incorrect** match between organ, sensory cell and type of receptor from the table below.

Organ	Sensory cells	Type of Receptor
I. Tongue II. Ear III. Nose IV. Eye	1. Cone cells 2. Chemoreceptor cells 3. Hair cells 4. Taste bud	a. Chemoreceptor b. Photoreceptor c. Mechanoreceptor

A. I, 4, a
B. II, 3, c
C. III, 2, c
D. IV, 1, b

Answer: C $\longrightarrow$ Clear

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9. A woman who has four sisters married to a man who has three brothers and one sister. What is the usual probability of having a son if they have a child?

   A. 12.5%
   B. 25%
   C. 50%
   D. 75%

   Answer: C. The probability to get a boy or a girl is always fifty- fifty

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10. In a chemical reaction, when calcium changes (atomic number, Z = 20) to form calcium ions, the ions react with carbonate ions. In this reaction each calcium atom:

    A. releases one electron
    B. releases two electrons
    C. gains two electrons
    D. increases atomic number by two

    Answer: B

    ${}_{20}Ca \longrightarrow {}_{20}Ca^{+2} + 2e^{-}$

    ${}_{20}Ca$ Calcium atom has 20 electrons

    ${}_{20}Ca^{+2}$ Calcium ion has 18 electrons

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11. X is a white solid substance. When X is heated, it produces a white solid substance Y and gas Z. The produced gas in the reaction is similar to the gas produced by burning carbon in excess of oxygen, and Y is an oxide. From this information, it can be concluded that:

    A. X, Y and Z are compounds
    B. Only X and gas Z are compounds
    C. Y is an element and gas Z is a compound
    D. X and Y are pure compounds

    Answer: A

    The reaction: X (s) $\longrightarrow$ Y (s) + Z (g) ↗

    Z is CO_2(g) which produced from oxidation of carbon:

    $C(s) + O_2(g) \longrightarrow CO_2(g)$

    Substance X is a carbonate salt, such as MCO_3 (for example M = Ca, Mg, Ba) (a white solid) substance X is MCO_3 and if MCO_3 is heated, the metal oxide (white solid) and CO_2 (carbon dioxide) gas will be formed.

    $MCO_3(s) \longrightarrow MO(s) + CO_2(g)$

    White white colorless

For test problems No. 12 and 13, read the statement below:

Hypertension is one of diseases that can cause death. The disease is indicated by a high blood pressure (above normal, higher than 140/90 mm Hg). The term blood pressure usually refers to the force pushing against an arterial wall. Hypertension can increase the risk of heart attacks, heart disease, strokes and kidney failure. Hypertension might be related to increasing of sodium ion concentration [atomic mass (A) of sodium = 23; atomic number (Z) = 11]. Diet plays important role in hypertension, additional food such as orange, banana and vegetables could reduce blood pressure. Based on the study, orange, banana and vegetables contain potassium ion, K (A = 39, Z = 19). Fifteen out of twenty people that take those diets have reduction of blood pressure (diastolic & systolic) with obvious reduced of diastolic up to 2.4 mm Hg.

12. Active metal ion that present in orange, banana and vegetable contains .... electrons and ……………protons

A. 10 and 11
B. 11 and 11
C. 18 and 19
D. 19 and 19

Answer = C
Solution
The active metal ion is K^+, which contains 18 electrons and 19 protons

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13. Based on the above research, hypertension and the kidney failure might indicate

A. imbalance of Na^+ / K^+
B. failure of Na^+ / K^+ re-absorption
C. substitution of Na^+ by K^+
D. retention of K^+ or Na^+

Answer = A
Solution
Hypertension is due to excess of Na^+ which can be balanced by K^+ .
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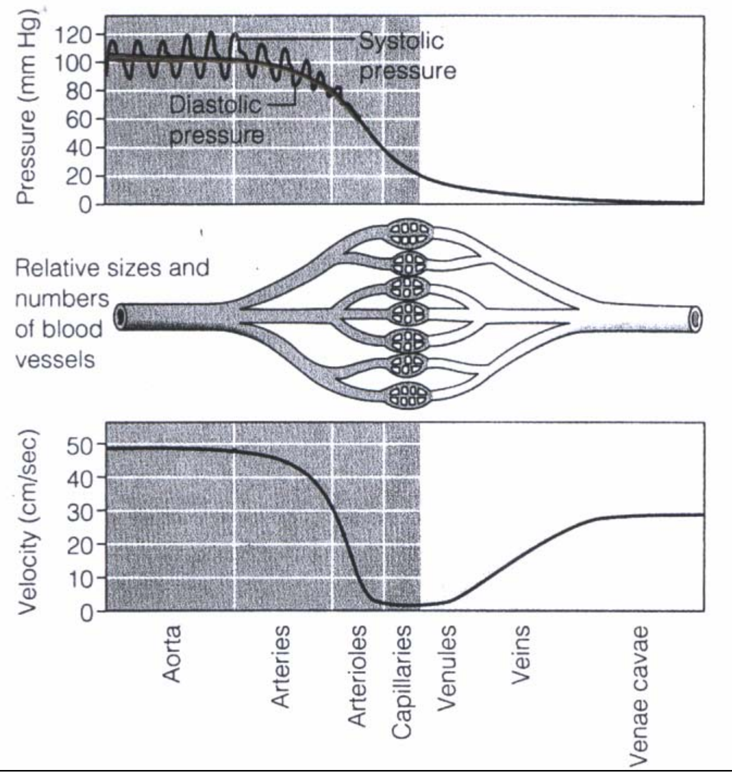
For Test Problem No: 14 and 15

Blood Circulatory System

The following curves show the pressure and velocity variation in the blood as it moves through the systemic circulatory system for a normal adult human. From the aorta the blood flows into the major arteries, then into the smaller arteries (arterioles), and finally into the capillaries. At each stage, these blood vessels are divided into many smaller vessels. The fluid flow (Q, volume/unit time) equal to pressure difference divided by R (**$Q = \Delta P/R$**), where R is the fluid resistance of a single vessel. This equation is also valid for a complex network of interconnected vessels, such as the blood vessels in the circulatory system when R is taken to be the total resistance of the network.



14. If the radius (r) of the aorta is about 0.9 cm, use the data from the figure to estimate the flow rate of the blood Q:

A. $1.3 \times 10^{-4}\ m^3/s$
B. $2.8 \times 10^{-4}\ m^3/s$
C. $1.2 \times 10^{4}\ m^3/s$
D. $1.3 \times 10^{4}\ m^3/s$

Answer =A
Solution
The flow rate $Q = vA = v\pi r^2 = 0.5\ m/s \cdot \pi\ (9 \times 10^{-3}\ m)^2 = 1.3 \times 10^{-4}\ m^3/s$
==

15. Assume $Q = 1.0 \times 10^{-4}\ m^3/s$, then the total fluid resistance R of all the arteries, arterioles, and capillaries in the body is: (density of mercury = 13,600 kg/m^3)

A. $1.1 \times 10^{-7}\ kg\ m^{-4}\ s^{-1}$
B. $15\ kg\ m^{-4}\ s^{-1}$
C. $1.2 \times 10^{4}\ kg\ m^{-4}\ s^{-1}$
D. $1.1 \times 10^{8}\ kg\ m^{-4}\ s^{-1}$

Answer = D

Solution

From the figure above, if v = 0.5 m/s, the pressure difference is about 80 mmHg = 0.08 m x13600 kg/m^3 x 9.8 m/s^2 = 10,662 Pa

Q = ΔP/R m^3/s → R = ΔP/Q = 10,662 Nm^{-2}/ 1.0 x 10^{-4} m^3/s = 1.1 x 10^8 kg m^{-4} s^{-1}

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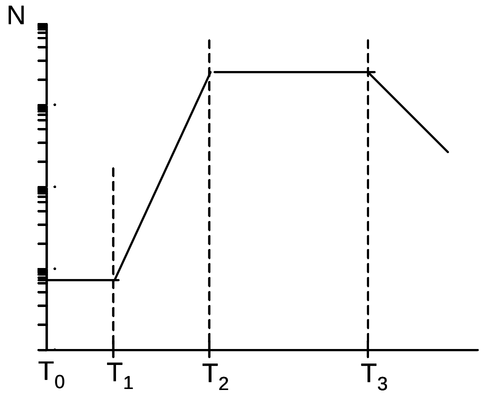
For Test Problems No: 16, 17, 18

Population Growth Pattern of Bacteria

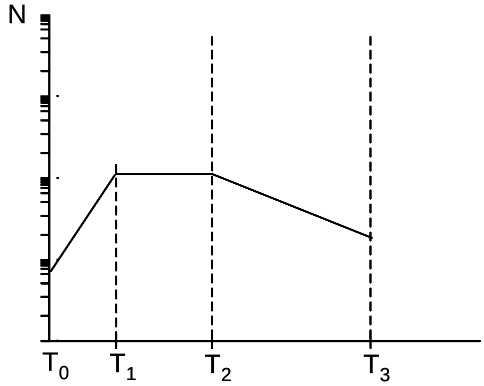
Population growth pattern of bacteria is very important in a fermentation industry. If an Erlenmeyer flask containing nutrient broth was inoculated by a certain amount of bacterial cells (N_o) at T_o, after a certain period of time the bacteria will show a specific growth curve. In the beginning of growth (T_o – T_1) the cells are under adaptation phase. After adaptation phase, cells start to multiply by binary fission process. Each cell will divide, and become two cells. In a closed system where the nutrient supply is limited, the population of dividing cells will become relatively the same amount with the dead cells (T_2 – T_3). After T_3 the amount of dead cells will be higher than the living ones, then eventually all cells will die.

16. The growth curve (N in logarithmic scale) from the above description is:

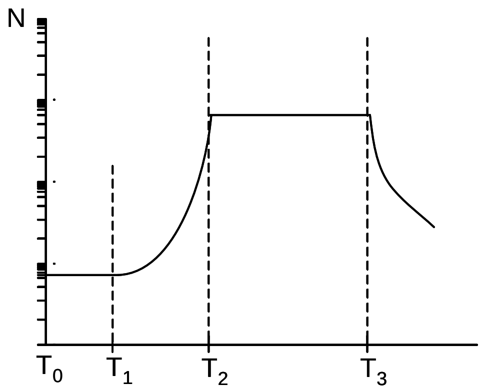
A.



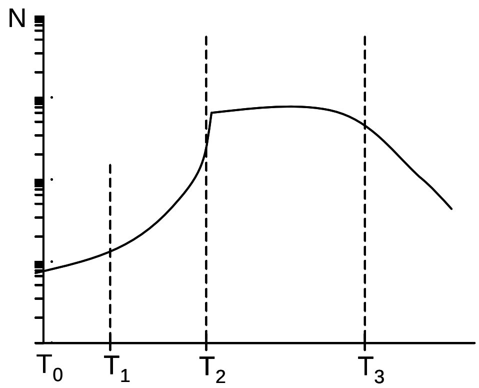
B.



C.



D.



Answer: A → Clear

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17. Suppose 2×10^2 cells are inoculated (T_o) and the generation time (T_g) is 30 minutes, calculate the amount of the cells after 5 hours (ignore the adaptation time):

A. 2000
B. 4000
C. 2.05×10^5
D. 1.02×10^{23}

Answer: C

Solution:

Each cell will divide, and become two cells continuously, so it can be formulated by
$N = N_o\, 2^n$
where $n = T/T_g$
$N = 200 \times 2^{(5/0.5)} = 2.05 \times 10^5$

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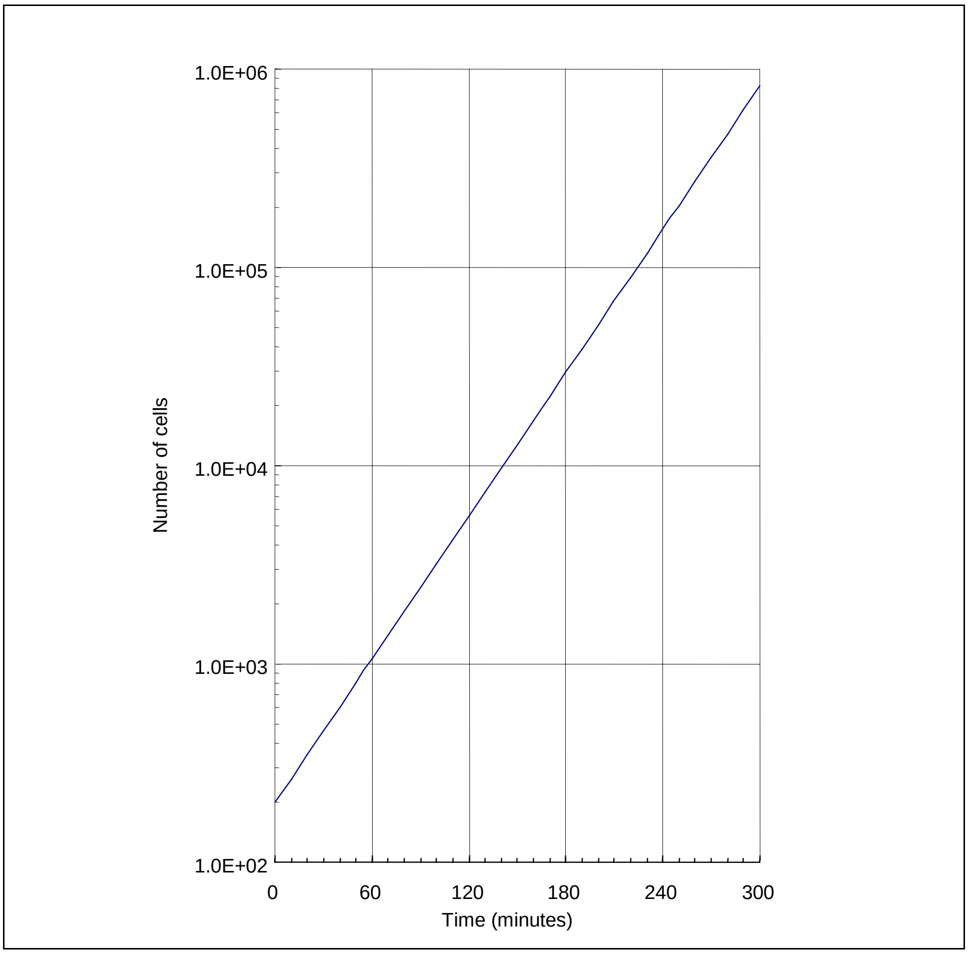
18. The relation of cells population as a function of time can be depicted in the figure below: ($1.0E+06 = 10^6$)



Based on the figure above, the generation time of the cells is approximately:

A. 10 minutes
B. 25 minutes
C. 35 minutes
D. 40 minutes

Answer : B

Solution

By using the equation N = $N_o\ 2^n$, and n = T/T_g, the equation becomes:

log N = log N_o + T/T_g log 2 or $\log N = \log N_o + \frac{\log 2}{T_g} t$, gradient curve is $\frac{\log 2}{T_g}$. Taking any two points the gradient of the curve can be calculated.

Example:

Point 1 : N_1 = 200, T_1 = 0 minutes

Point 2 : N_2 = 2 x 10^5 , T_2 = 250 minutes

Mean Δlog N_1 = 3 dan ΔT = 250 minutes

Gradient curve = 3/250 minutes^{-1} = 0.012 mins^{-1} → T_g = (log 2)/0.012 ~ 25 minutes

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For Test Problems No. 19, 20

Photosynthesis

Plants need water to produce food by photosynthesis process. The water is transported through specific structures with a speed of 75 cm/min. The plant efficiency in using the water can be determined through the ratio of transpiration to photosynthesis. The ratio can be calculated by the loss of water in every gram of CO_2 used in assimilation. The common ratio is 1:600. During the photosynthesis, carbon-dioxide diffuses into the leaf tissue and oxygen produced diffuses from stomata in the leaf.

19. Based on the description above, the reaction that occurred is:

A. $6\ CO_2 + 6\ H_2O + \text{Energy} \longrightarrow C_6H_{12}O_6 + 6\ O_2$

B. $6\ CO_2 + 6\ H_2O + \text{Energy} \longrightarrow C_6H_{11}O_6 + 6\ O_2 + \frac{1}{2} H_2$

C. $2\ CO_2 + 3\ H_2O + \text{Energy} \longrightarrow C_2H_5OH + 3\ O_2$

D. $6\ CO_2 + 3\ H_2O + \text{Energy} \longrightarrow C_6H_6 + \frac{15}{2}\ O_2$

Answer : A ⟶ clear

20. How many liters of CO_2 (at T = 0 ^{o}C, P = 1 atm) are required for transpiration of 600g water?

A. 373 L

B. 747 L

C. 1467 L

D. 1494 L

Answer : B

Solution :

$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2 + E$

mole of H_2O = mole of CO_2 = 600 : 18 = 33.33 mol

Volume of CO_2 = 33.33 x 22.4 L = 747 L.

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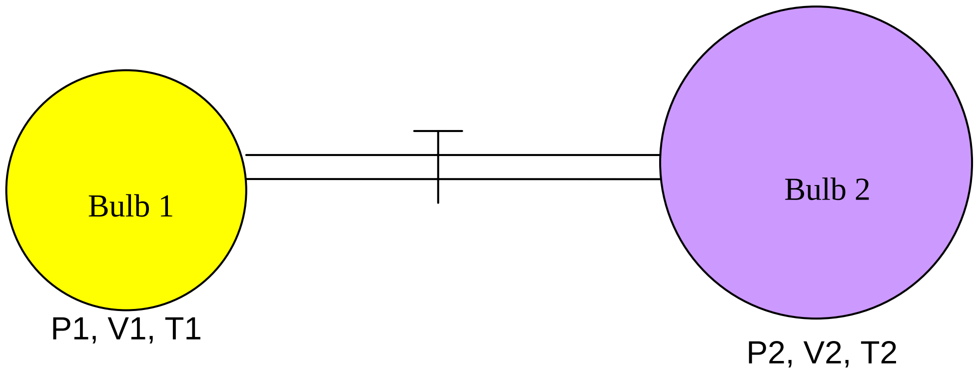
For Test Problem No. 21, 22



In a perfect isolated system, two bulbs are connected with a valve (see Figure above). Both bulbs are filled with a fresh air. When the valve is in closed position, the air in the first bulb has a pressure P_1, volume V_1 and temperature T_1, and the air in the second bulb has a pressure P_2, volume V_2, and temperature T_2. The temperature of $T_1 = T_2$ and $V_2 = 2.8\ V_1$.

21 What is the final pressure (P) of the system if the valve is opened (assume the air in the bulb is an ideal gas)?

A. $\dfrac{P_1 + 2.8P_2}{3.8}$

B. $\dfrac{2.8P_1 + P_2}{3.8}$

C. $\dfrac{P_1 + 0.8P_2}{0.8}$

D. $\dfrac{3.8P_1 + P_2}{2.8}$

Answer: A

Solution

For T= contants, we have:

$$P(V_1+2.8V_1) = P_1 V_1+P_2\cdot 2.8V_1$$

$$P = \frac{(P_1 + 2.8P_2)(V_1)}{3.8(V_1)}$$

A. $P = \frac{P_1 + 2.8P_2}{3.8}$

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22. If the first bulb is filled by CO gas with pressure of 2 atm and the second bulb is filled by O_2 with pressure of 1 atm. The valve is opened, the gas CO in the first bulb and gas O_2 in the second bulb would mix and react completely according to the following reaction:

$2\,CO_{(g)} + O_{2\,(g)} \rightarrow 2\,CO_{2\,(g)}$

After reaction take place completely, the gas in both bulbs consist of :

A. CO, O_2, and CO_2
B. CO and CO_2
C. O_2 and CO_2
D. only CO_2

Answer C

Solution

5 mole CO equivalent to 2.5 mole O_2
There is an excess of O_2, therefore all CO reacts completely
The gas after reaction consists of : CO_2 and unreacted O_2,

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23. Mars' period (the time needed for one revolution about the Sun) is 684 days (Earth-days). Find the force on the Mars (m_M = 6.59 x 10^{23} kg) due to the gravitational attraction of the Sun (m_S = 1.99 x 10^{30} kg), if the distance of the Earth from the Sun is 1.50 x 10^{11} m. The universal gravitation constant G is 6.67 x 10^{-11} Nm^2/kg^2.

A. 5.82 x 10^{20} N
B. 1.09 x 10^{21} N
C. 1.68 x 10^{21} N
D. 8.96 x 10^{21} N

Answer : C

Solution:

$$From\ Kepler's\ third\ law: \frac{r_{mars-sun}}{r_{earth-sun}} = \left(\frac{T_m}{T_E}\right)^{2/3}$$

$$= \left(\frac{687}{365}\right)^{2/3}$$

$$= 1{,}52$$

$$so \quad r_{mars-sun} = 1.52 \times r_{earth-sun} = 1.52 \times 1.5 \times 10^{11}\,m$$

$$= 2{,}28 \times 10^{11}\,m$$

The force on the Mars due to the Sun is :

$$F_{ms} = G\frac{m_m m_s}{r_{ms}^2} = \frac{\left(6.67 \times 10^{-11}\,N.m^2 / kg^2\right) \cdot m_m \cdot m_s}{r_{ms}^2}$$

$$= \frac{8.73 \times 10^{43}\,Nm^2}{\left(2.28 \times 10^{11}\,m\right)^2}$$

$$= 1.68 \times 10^{21}\,N$$

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24. A baby boy was born with a hemophilia disease. What is the possibility of his parents' gene related to this disease?

A. The mother is hemophilia, the father is normal
B. The mother and father are both hemophilia
C. The mother carries hemophilia gene
D. The father carries hemophilia gene

Answer: C.

The mother is a carrier of hemophilia gene but she is not hemophilia (hemophilia is lethal for women if it is homozygote)

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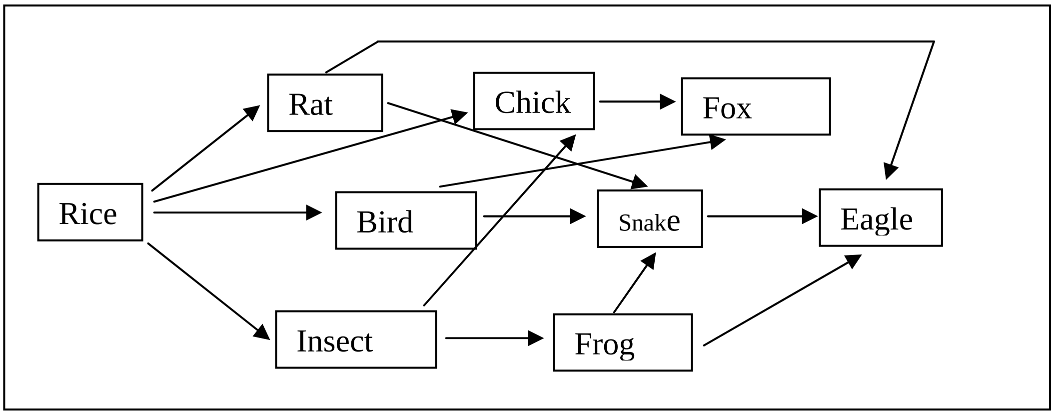
25. Look at the picture carefully! The secondary and the tertiary consumers are:



A. Frog, snake
B. Frog, eagle
C. Snake, eagle
D. Fox, snake

<u>Answer : C</u>

Primary consumer: herbivore; Secondary Consumer : carnivore 1; Tertiary consumer: consumer 2;