13th INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

IJSO

BALI, INDONESIA 2016

Science for Creative Innovation

MULTIPLE CHOICE COMPETITION

--- SOLUTIONS ---

DECEMBER, 4th 2016

1. Answer: C

Explanation:

The reaction is $CaCl_{2\,(aq)} + Na_2CO_{3\,(aq)} \rightarrow CaCO_{3(s)} + 2NaCl_{(aq)}$

Mol of Na_2CO_3 = 50 mL x 0.15 M = 7.5 x 10^{-3} mol

Mol of $CaCl_2$ = Mol of Na_2CO_3 = 7.5 x 10^{-3} mol

Volume of $CaCl_2$ = 7.5 x 10^{-3} mol/0.25 M= 0,03 L = 30 mL

2. Answer: B

Explanation:

Catalyst is a substance that changes the rate of a chemical reaction without itself being used up. Although the catalyst is not part of the overall reaction its does participate by changing the mechanism of the reaction. The catalyst provides a path to the products that has a rate-determining step with a lower activation energy than that of the uncatalyzed reaction. Therefore, statements (2) and (4) are correct.

3. Answer: A

Explanation:

Electron has its own orbital energy, when it move up to the higher energy, there should be absorbed energy which is equal to the difference between to orbitals. So the correct answer is A.

4. Answer: A

Explanation:

Mol of bioethanol = (13.8g : 46 g/mol) = 0.3 mol

Mol of oxygen = (19.2 g : 32 g/mol) = 0.6 mol

Since 0.3 mol bioethanol requires 0.9 mol of oxygen, oxygen becomes the determining reactant, so the calculation is based on the mol of oxygen.

The volume of CO_2 = (0.6 mol x 22.4 L/mol) x 2/3 = 8.96 L.

5. Answer: A

Explanation:

$$HIn \rightleftharpoons H^+ + In^-$$

$$Ka = \frac{[H^+][In^-]}{[HIn]}$$

$$\frac{[In^-]}{[HIn]} = \frac{Ka}{[H^+]} = \frac{1\times10^{-5}}{1\times10^{-3}} = \frac{1}{100}$$

There is 10 times as much as HIn as In^-, and the colour that we see is due to HIn (yellow).

6. Answer: D

Explanation:
K^+, Ar and Cl^- have the same electronic configuration, but they have the nuclear charge increases in the order $K^+ > Ar > Cl^-$, so the order of the ionization potential is $Cl^- < Ar < K^+$.

7. Answer: B

Explanation:
$H_2A + 2KOH \rightleftharpoons K_2A + 2H_2O$

mmol KOH = 40.0 x 0.100 = 4 mmol

mmol H_2A = 0.5 x mmol NaOH = 2 mmol

Molecular mass of H_2A = 0.244 g / 2 mmol = $0.244/2.10^{-3}$ g/mol = 122 g/mol.

8. Answer: C

Explanation:
Carbon = 6/1 x 30 gram = 180 gram

9. Answer: C

Explanation:
Unpolluted rain is slightly acidic due to the absorption of atmospheric carbon dioxide to partly form carbonic acid.

$$CO_{2\,(g)} + H_2O \rightleftharpoons H_2CO_{3(aq)}$$

Carbonic acid is weak acid and the pH of water in equilibrium with atmospheric carbon dioxide is approximately 5.6

10. Answer: B

Explanation:
The solute is a strong acid, our first thought is that the solution should be acidic.
$HCl + H_2O \rightarrow H_3O^+ + Cl^-$
as HCl is strong acid, we may consider that the dissociation is complete therefore

[H3O+] from the HCl is equal to [HCl] = 5.0×10^{-8} M.

[H3O+] from the dissociation of water is 1.0×10^{-7} M.

Therefore the total [H3O+] in the solution is

$(5.0\times10^{-8}\ M + 1.0\times10^{-7}\ M) = 1.5\times10^{-7}\ M$

$pH = -\log(1.5\times10^{-7}) \cong 6.9$

if we consider the effect of two equilibrium we will get the answer $\cong 6.9$

11. Answer: A

Explanation:

The total volume V_{total} of a sample is

$$V_{total} = V_{grains} + V_{voids}$$

From the void ratio

$$e = \frac{V_{voids}}{V_{grains}} \rightarrow V_{voids} = eV_{grains}$$

By substiting this equation to the total volume, V_{total} , and solving for V_{grains} , we find

$$V_{grains} = \frac{V_{total}}{1+e}$$

The total mass m_{sand} of the sand grains is the product of the density of silicon dioxide ρ_{SiO_2} and the total volume of the sand grains:

$$m_{sand} = \rho_{SiO_2} V_{grains} \rightarrow m_{sand} = \rho_{SiO_2} \frac{V_{total}}{1+e}$$

Since, the total mass m_{sand} of the sand grains is also the product of the sand density ρ_{Sand} and the total valume of the sample, we find

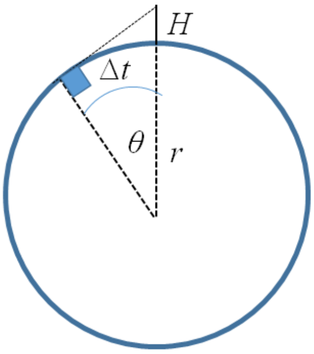
$$\rho_{Sand} V_{total} = \rho_{SiO_2} \frac{V_{total}}{1+e} \rightarrow \rho_{Sand} = \frac{\rho_{SiO_2}}{1+e}$$

Using the numerical values of e and ρ_{SiO_2}, we find that $\rho_{Sand} = 1.58 \times 10^3$ kg/m^3.

12. Answer: B

Explanation:

A schematic diagram of the observation process is given in figure below.



The angle θ is achieved during elaps time, which can be calculated using a comparison with a complete rotation on its axis every twenty-four hours. Therefore, we have,

$$\frac{\theta}{360^0} = \frac{\Delta t}{24\,\text{hours}} \rightarrow \theta = \frac{11.1}{86400\,\text{s}} 360^0 = 0.046^0$$

The radius of Earth can be estimated using trigonometric of the triangle as shown in the figure. Here, we have

$$\cos\theta = \frac{r}{r+H} \quad \rightarrow r = H\frac{\cos\theta}{1-\cos\theta} = 1.7\frac{\cos(0.046)}{1-\cos(0.046)} = 5.3\times10^6\,\text{m}$$

13. Answer: D

Explanation:

Let d_1 and d_2 be the distance between the two upper plates and the two lower plates, respectively. Therefore, from the Figure we see that

$$d_1 + d_2 = a - b$$

The capacitance for each capacitor can be written as

$$C_1 = \frac{\varepsilon_0 A}{d_1}, \quad C_2 = \frac{\varepsilon_0 A}{d_2}$$

Therefore, the total capacitance in series can be expressed as

$$C_{tot} = \frac{C_1 C_2}{C_1 + C_2} = \frac{\varepsilon_0 A}{d_1 + d_2} = \frac{\varepsilon_0 A}{a - b}$$

Furthermore, the total energy stored in the capacitors is given by

$$W = \frac{CV_0^2}{2} = \frac{\varepsilon_0 A V_0^2}{2(a-b)}$$

When the center section is removed, the energy stored in the capacitor becomes

$$W' = \frac{\varepsilon_0 A V_0^2}{2a}$$

Finally, the change in the energy stored in the capacitors is

$$\Delta W = W - W' = \frac{\varepsilon_0 A V_0^2}{2(a-b)}\left(\frac{b}{a}\right)$$

14. Answer: A

Explanation:
We imagine that the ends of both bolts expand into the gap between them as the temperature rises. We categorize this as a thermal expansion problem, in which the sum of the changes in length of the two bolts must equal the length of the initial gap between the ends. This leads to the fact that

$$\Delta L_{Br} + \Delta L_{St} = 5\times 10^{-6}$$

Here,

$$\Delta L_{Br} = \alpha_{Br} L_{i=Br} \Delta T$$

And

$$\Delta L_{St} = \alpha_{St} L_{i=St} \Delta T$$

Where α_{Br} and α_{St} are thermal expansion coefficient for brass and steel, respectively, while $L_{i=Br}$ and $L_{i=St}$ are the initial length of brass and steel, respectively.

Using all above equation, we find that

$$5\times 10^{-6} = \alpha_{Brt} L_{i=Br} \Delta T + \alpha_{St} L_{i=St} \Delta T \rightarrow \Delta T = \frac{5\times 10^{-6}}{\alpha_{Brt} L_{i=Br} + \alpha_{St} L_{i=St}}$$

$$\Delta T = \frac{5\times 10^{-6}}{19\times 10^{-6}(0.03) + 11\times 10^{-6}(0.01)} = 7.4$$

Finally, the temperature at which the bolts touch is 27°C + 7.4°C = 34.4°C.

15. Answer: D

Explanation:

The weight of the iceberg is

$$W_{iceberg} = m_{iceberg} g = \rho_{iceberg} V_{iceberg} g$$

where $\rho_{iceberg}$ is the density of the iceberg and $V_{iceberg}$ is the whole volume of iceberg. The magnitude of the upward buoyant force equals the weight of the displaced water:

$$W_{water} = m_{water} g = \rho_{water} V_{water} g$$

where ρ_{water} is the density of the water and V_{water} is the volume of displaced water. V_{water} is equal to the volume of the ice beneath the water (the shaded region in the Fig). Since the system is an equilibrium, the fraction of ice beneath the water's surface can be calculated by

$$W_{iceberg} = W_{iceberg} \rightarrow f = \frac{V_{water}}{V_{iceberg}} = \frac{\rho_{iceber}}{\rho_{water}} = \frac{917}{1030} = 0.890$$

16. Answer: C

Explanation:

On a level (unbanked) road, the force that causes the centripetal acceleration is the force of static friction between car and road. However, if the road is banked at an angle θ, as in Figure, the normal force **n** has a horizontal component, n_x,

$$n_x = n\sin\theta$$

pointing toward the center of the curve. Because the ramp is to be designed so that the force of static friction is zero, only the component n_x causes the centripetal acceleration. Hence, Newton's second law for the radial direction gives

$$F_r = n_x \rightarrow m\frac{v^2}{r} = n\sin\theta$$

On the other hand, the car is in equilibrium in the vertical direction. Thus, from $\sum F_y = 0$ we have

$$n\cos\theta = mg$$

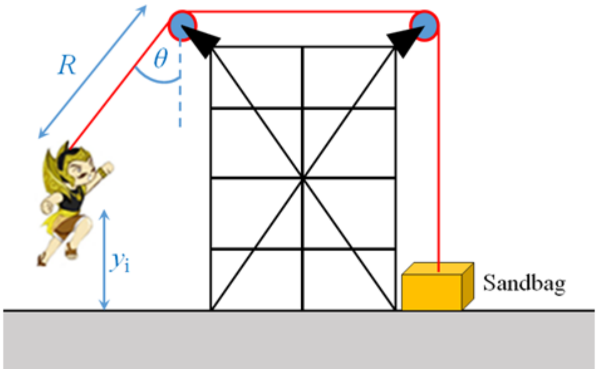
Dividing the previous equation with above equation, we find that

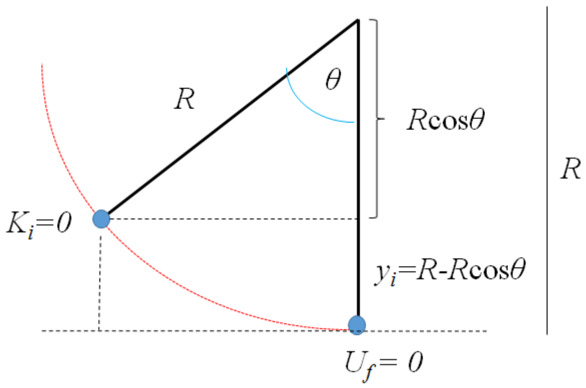
$$\tan\theta = \frac{v^2}{rg} \rightarrow \theta = \tan^{-1}\left(\frac{(13.4)^2}{50\times 9.8}\right) = 20.1^0$$

17. Answer: C

Explanation:

Let us imagine what happens as the actor approaches the bottom of the swing. At the bottom, the cable is vertical and must support his weight as well as provide centripetal acceleration of his body in the upward direction. At this point, the tension in the cable is the highest and the sandbag is most likely to lift off the floor.





At the swinging of the actor from the initial point to the lowest point, we categorize this as an energy problem involving an isolated system that is the actor and the Earth. Here, we find that

$$K_f + U_f = K_i + U_i \rightarrow \frac{1}{2} m_{actor} v_f^2 + 0 = 0 + m_{actor} g y_i$$

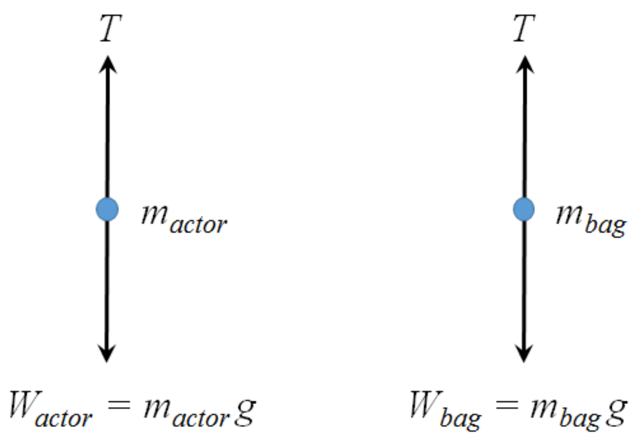
where y_i is the initial height of the actor above the floor and v_f is the speed of the actor at the instant before he lands. It is noted that $K_i = 0$ because he starts from rest and that $U_f = 0$ because we define the configuration of the actor at the floor as having a gravitational potential energy of zero. Here, y_i is related to R and θ through the relation (see figure),

$$y_i = R - R\cos\theta$$

Then, we have

$$v_f^2 = 2gR(1-\cos\theta)$$

At the lowest point, the tension in the cable is transferred as a force applied to the sandbag, we categorize the situation at this instant as a Newton's second law problem. We apply Newton's second law to the actor at the bottom of his path, using the free-body diagram as shown below.



Here, for the mass of actor, we have,

$$\sum F_y = m_{actor}\frac{v_f^2}{R} \rightarrow T - m_{actor}g = m_{actor}\frac{v_f^2}{R}$$

$$T = m_{actor}g + m_{actor}\frac{v_f^2}{R}$$

$$T = m_{actor}g + m_{actor}2g(1-\cos\theta)$$

And for the mass of sandbag, we have,

$$T = m_{bag}g \quad \rightarrow \; m_{actor}g + m_{actor}2g(1-\cos\theta) = m_{bag}g$$

$$\theta = \cos^{-1}\left(\frac{3m_{actor} - m_{bag}}{2m_{actor}}\right) = \cos^{-1}\left(\frac{3(65)-130}{2(65)}\right) = \cos^{-1}(0.5) \quad = 60^0$$

18. Answer: C

Explanation:

The electron acceleration in *y*-direction,

$$a_y = -\frac{F}{m} = \frac{-eE}{m} = -\frac{eV}{md}$$

The velocity in *x*-direction is

$$v_x = v_0 \cos\alpha = v_0$$

The horizontal distance is

$$x = v_x t = v_o t$$

The velocity in *y*-direction

$$v_y = v_0 \sin\alpha + a_y t = -\frac{eV}{md}t$$

The vertical position is

$$y = \frac{d}{2} - \frac{eV}{2md}t^2$$

When the electron hit the positive plate, $y = 0$, we find that

$$t = d\sqrt{\frac{m}{eV}}$$

So that the horizontal distance becomes

$$x = v_0 d\sqrt{\frac{m}{eV}}$$

19. Answer: C

Explanation:

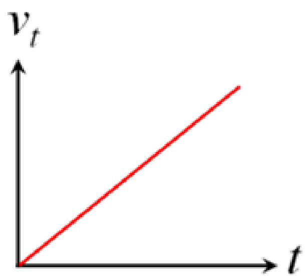
The force done by the magnetic field across to the wires is

$$F = ma = BId \rightarrow m\left(\frac{v_t - v_0}{t - t_0}\right) = BId$$

Since the wires is initialy at rest, $v_0 = 0 \rightarrow t = 0$, we find

$$v_t = \frac{BId}{m} t$$

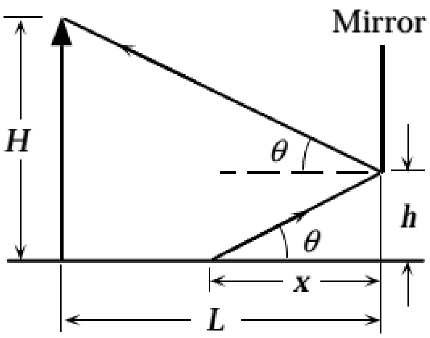
Therefore, v_t linearly depends on the time t, which is given in the following Figure,



20. Answer: B

Explanation:

From the figure, it is clearly seen that the angle of incidence is the angle of reflection.



Thus we have,

$$\tan\theta = \frac{H-h}{L} = \frac{h}{x} \rightarrow x = \frac{Lh}{H-h}$$

Here, H = 1.68 m, h = 0.43 m, and L = 2.2 m, we find that

$$x = \frac{Lh}{H-h} = \frac{2.2 \times 0.43}{1.68 - 0.43} = 0.757\,\text{m}$$

21. Answer: A

Explanation:

Female silkworm moths (*Bombyx mori*) attract males by emitting chemical signals that spread through the air. A male hundreds of meters away can detect these molecules and fly toward their source. The sensory organs responsible for this behavior are the comblike antennae visible in the photograph shown here. Each filament of an antenna is equipped with thousands of receptor cells that detect the specific sex attractant.

22. Answer: B

Explanation:

Slope of Bt ORG2 (0,5245) is greater than slope of Bt ORG1 (0,2069)

LC50 of Bt ORG1 during 24 hours = 3.15 x 10^{10}cell/mL is greater than LC50 of Bt ORG2 during 24 hours = 2.15 x10^{10}cell/mL

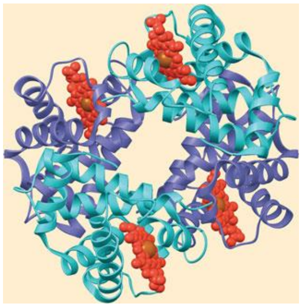
23. Answer: D

Explanation:

Centriole: One of a pair of small, cylindrical organelles lying at right angels to each other near the nucleus in the cytoplasm of animal cells and certain protist and plant cells.

24. Answer: B

Explanation:



Hemoglobin, the oxygen-binding protein of red blood cells shown below, is another example of a globular protein with quaternary structure. It consists of four polypeptide subunits, two of one kind (α) and two of another kind (β). Both α and β subunits consist primarily of α-helical secondary structure. Each subunit has a non-polypeptide component, called heme, with an iron atom that binds oxygen.

25. **Answer: A**

Phloem

26. **Answer: B**

Explanation:

The plasmodium-carrying mosquito is still survive because there are not bird predator and monkey Species B is not immune to plasmodium

27. **Answer: A**

Explanation: Mutualism

The ants get nutrients produced by the acacia

28. **Answer: B**

Explanation:

Human has dozens of antigens on the surface of his/her blood cells. One group of antigens, designated as the MN blood group, stimulates the production of antibodies when injected into rabbit. Allele for MN blood groups, usually designated as M and N, are codominant. It means that Genotype MM produces only antigen M, while genotype NN produces only antigen N, and the heterozygous genotype MN produces both antigens. Given the following data:

Genotype	Observed
MM	320
MN	480
NN	200
Total	1000

Because 1000 diploid individuals are in the sample, there are a total of 2000 allele. By the Hardy-Weinberg principle, the sum of allele frequencies is p + q = 1. What is the frequency of allele M?

$$M = \frac{(2 \times 320)}{2000} = 0.56$$

29. Answer: A

Explanation:

Embryo:

In plant the young sporophyte produced following fertilization and subsequent development of the zygote.

30. Answer: D

Explanation:

The Calvin Cycles: Cyclic series of reaction in the chloroplast stroma in photosynthesis; fixes CO_2 and produced carbohydrate