1. Chalk is composed of calcium carbonate, $CaCO_3$. This water-insoluble compound is formed when a solution of calcium chloride is added to a solution of sodium carbonate. How many milliliters of 0.25 M calcium chloride are needed to react completely with 50 mL of 0.15 M Na_2CO_3 solution?
   A. 10
   B. 15
   C. 30
   D. 60

2. Zeolite as a porous material is often used as catalyst. Which of the following statements are CORRECT concerning catalyst.
   (1) Catalyst increases the equilibrium constant of the reaction.
   (2) Catalyst decreases the activation energy of the reaction.
   (3) Catalyst is not involved in the reaction.
   (4) Catalyst increases the rate of reaction.
   A. (1) and (2)
   B. (2) and (4)
   C. (3) and (4)
   D. (1) and (4)

3. An electron moves up from K (n=1) shell to M (n=3) shell. The correct statement concerning the phenomenon is ...
   A. electron absorbs energy equal to shell energy M minus shell energy K
   B. electron absorbs energy equal to shell energy K minus shell energy M
   C. electron emits energy equal to shell energy M minus shell energy K
   D. electron emits energy equal to shell energy K minus shell energy M

4. Bioethanol (C_2H_5OH) can be used as alternative fuel in accordance with the following combustion reaction:
   $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ + Energy
   If 13.8 g bioethanol is burnt with 19.2 g O_2, the volume of CO_2 gas emitted to the air when it is measured at standard condition (STP) is ... (A_r C=12, O=16, H=1)
   A. 8.96 L
   B. 13.4 L
   C. 17.9 L
   D. 6.72 L

5. An indicator, HIn has an ionization constant, $K_a = 1 \times 10^{-5}$. If the aqueous solution containing non-dissociated molecular form (HIn) of the indicator has yellow color and the solution of In^- ion is green, what would be the color of the solution of this indicator when its pH is 3.0?
   A. yellow
   B. green
   C. pale yellow
   D. pale green

6. Arrange in order of increasing energy for removing an electron from $_{19}K^+$, $_{18}Ar$ and $_{17}Cl^-$
   A. $K^+ < Ar < Cl^-$
   B. $Ar < Cl^- < K^+$
   C. $Cl^- < K^+ < Ar$
   D. $Cl^- < Ar < K^+$

7. A 0.244 g sample of a diprotic acid requires 40.0 mL of 0.100 M of KOH for complete neutralization. The molecular mass of the acid is ...
   A. 244 g/mol
   B. 122 g/mol
   C. 61 g/mol
   D. 488 g/mol

8. A very effective anesthetic, cyclopropane, contains the elements carbon and hydrogen combined in a ratio of 1.0 g of hydrogen and 6.0 g of carbon. If a given sample of cyclopropane was found to contain 30.0 g of hydrogen, how many grams of carbon would it contain?
   A. 5
   B. 54
   C. 180
   D. 864

9. One of the major environmental concerns is the phenomenon of acid rain. Rain water in an unpolluted atmosphere will be ...
   A. neutral
   B. slightly basic
   C. slightly acidic
   D. strongly acidic

10. The pH of the solution of 5×10^{-8} M HCl at 25°C is ….
    A. 6.3
    B. 6.9
    C. 7.3
    D. 7.9

11. During an earthquake, a heavy object can sink into the ground if the shaking causes the ground to undergo liquefaction and the soil grains experience little friction as they slide over one another. The possibility of liquefaction in sandy ground can be predicted in terms of the *void ratio e* for a sample of the ground given by

$$e = \frac{V_{voids}}{V_{grains}}.$$

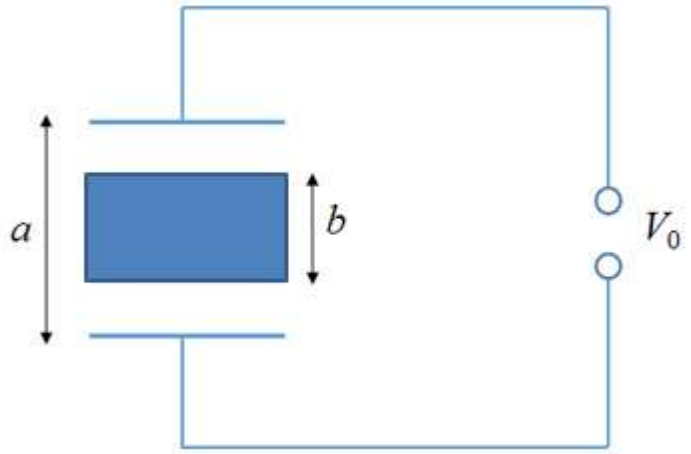
Here, V_{grains} is the total volume of the sand grains in the sample and V_{void} is the total volume between the grains (in the *voids).* If *e* exceeds a critical value of 0.650, liquefaction can occur during an earthquake. If the primary component of the sand mainly originates from solid silicon dioxide (SiO_2) with a density $\rho_{SiO_2} = 2.60\times10^3$ kg/m^3, what is the corresponding sand density, ρ_{sand}, at the critical point?

A. 1.58×10^3 kg/m^3
B. 1.69×10^3 kg/m^3
C. 2.43×10^3 kg/m^3
D. 4.00×10^3 kg/m^3

12. Indonesia is one of the countries in Asia that is located on the equator. Suppose you were lying on a beach close to the equator watching the sunset over a calm ocean. You start a stopwatch just after the top of the Sun disappears and immediately stand up, elevating your eyes to a height H = 1.70 m, and stop the stopwatch when the top of the Sun disappears again. If the elapsed time is Δt = 11.1 s and by assuming that the shape of the Earth is round, estimate the radius *r* of Earth based on your observation?

A. 4.83×10^6 m
B. 5.30×10^6 m
C. 6.61×10^6 m
D. 7.20×10^6 m

13. Consider two capacitors which are connected in series by the movable rigid center section made from metal of length b shown in the following Figure.



Capacitors constructed by using movable rigid center section

The area of each plate is A. If the voltage difference between the outside plates is kept constant at V0, what is the change in the energy stored in the capacitors if the center section is removed?

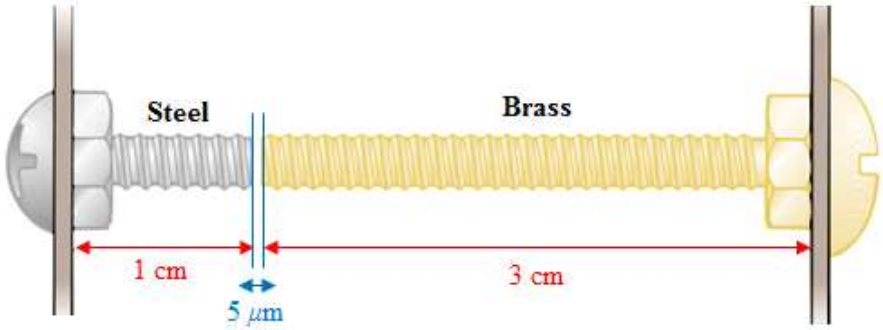
A. $\frac{\varepsilon_0 A V_0}{2(a-b)}\left(\frac{a}{b}\right)$

B. $\frac{\varepsilon_0 A V_0}{2(a-b)}\left(\frac{b}{a}\right)^2$

C. $\frac{\varepsilon_0 A V_0^2}{2(a-b)^2}\left(\frac{b}{a}\right)^2$

D. $\frac{\varepsilon_0 A V_0^2}{2(a-b)}\left(\frac{b}{a}\right)$

14. An electronic device has been poorly designed so that two bolts attached to different parts of the device almost touch each other in its interior, as shown in the following Figure.



Electronic device which consists of two different structures is shown

The steel and brass bolts are at different electric potentials and if they touch, a short circuit will develop, damaging the device. If the initial gap between the ends of the bolts is 5.00 μm at 27.0°C, at what temperature will the bolts touch? Thermal expansion coefficient for brass and steel are $19.0\times10^{-6}/^{0}$C and $11.0\times10^{-6}/^{0}$C, respectively.

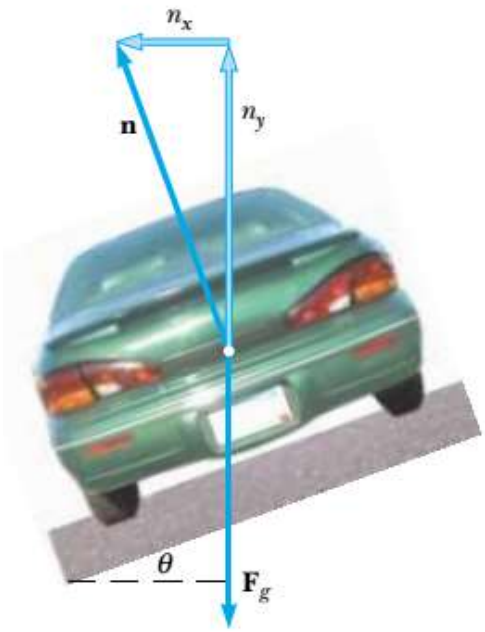
A. 34.4 ^{0}C
B. 36.6 ^{0}C
C. 42.9 ^{0}C
D. 46.2 ^{0}C

15. A floating iceberg in seawater, as shown in the Figure below, is extremely dangerous because most of the ice is below the surface.

This hidden ice could damage a ship that is still a considerable distance from the visible ice. Estimate what fraction of the iceberg lies below the water level if the density of seawater is 1030 kg/m^3 and the density of iceberg is 917 kg/m^3.

A. 0.352
B. 0.756
C. 0.781
D. 0.890

16. A civil engineer wishes to design a curved exit ramp for a highway in such a way that a car will not have to rely on friction to round the curve without skidding. In other words, a car moving at the designated speed can negotiate the curve even when the road is covered with ice. Such a ramp is usually banked; this means that the roadway is tilted toward the inside of the curve with the angle θ as shown in the following Figure.

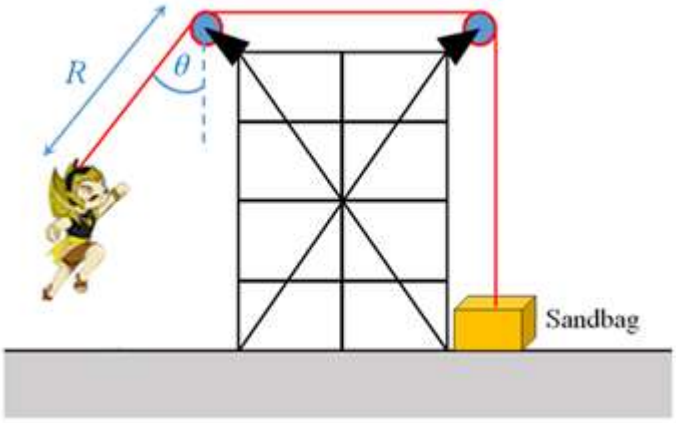


Schematic design of a curve exit ramp for highway

Suppose the designated speed for the ramp is 13.4 m/s and the radius of the curve is 50.0 m, at what angle θ should the curve be banked? (Acceleration due to gravity = 9.80 m/s^2)

A. 13.5^0
B. 17.9^0
C. 20.1^0
D. 28.3^0

17. You are designing an apparatus to support an actor of mass 65 kg who is swinging over the stage during the performance of a play. You attach the actor's harness to a 130-kg sandbag by means of a lightweight steel cable running smoothly over two frictionless pulleys as shown in the following Figure.

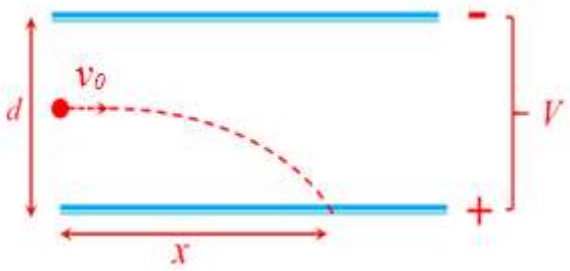


Schematic view of an apparatus used by an actor to fly down to the stage during the performance of a play.

You need 3 m cable between the harness and the nearest pulley so that the pulley can be hidden behind a curtain. For the apparatus to work successfully, the sandbag must never lift above the floor as the actor swings from above the stage to the floor. The initial angle that the actor's cable makes with the vertical θ. What is the maximum value θ can have before the sandbag lifts off the floor? (assume that the actor can be viewed as a point particle).

A. 30^0
B. 40^0
C. 60^0
D. 90^0

18. Two large horizontal metal plates are at a distance d apart. These plates are maintained at a potential difference V where the lower plate is positive as shown in the following Figure.



Schematic view of a beams electron motion under an electric field induced by two plates

A beam of electrons (with charges $-e$ and mass m) is introduced midway between the plates moving parallel to them at speed of v_0. At what horizontal distance x will the beam hit the positive plate? (The Gravitational force is ignored)

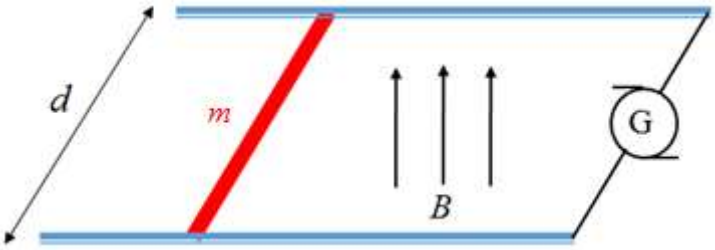
A. $\dfrac{v_0^2 dm}{2eV}$

B. $\dfrac{v_0 eV}{2dm}$

C. $v_0 d\sqrt{\dfrac{m}{eV}}$

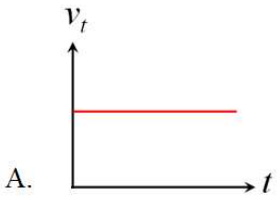
D. $v_o^2 d\sqrt{\dfrac{eV}{m}}$

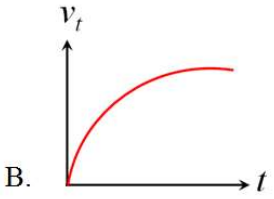
19. A metal wire of mass m slides without friction on two rails spaced of distance d apart, as shown in the Figure below. The track lies in a vertical uniform magnetic field **B**.

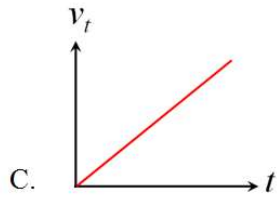


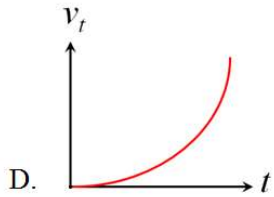
A metal wire slides without friction on two rails under homogenous magnetic fields

A constant current I flows through generator G along one rail, across the wire, and back down the other rail. Assume that at $t = 0$, the wire is initially at rest. Which ones the following figures is correct for the velocity v_t as a function of time t?

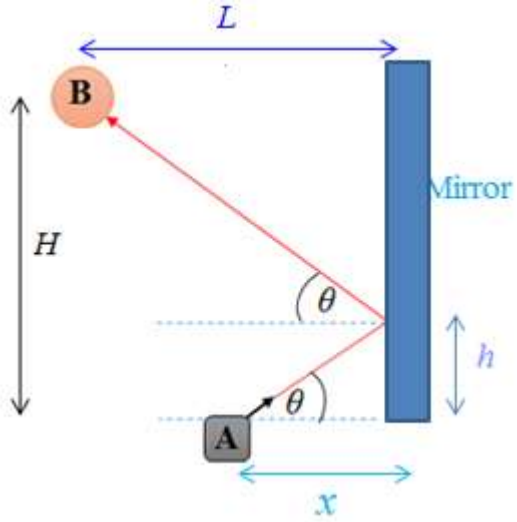
A. 

B. 

C. 

D. 

20. A light source device located on point **A** produces an incident light which is reflected by a mirror with the configuration as shown in the following Figure.



Schematic view of a light path from point A to point B

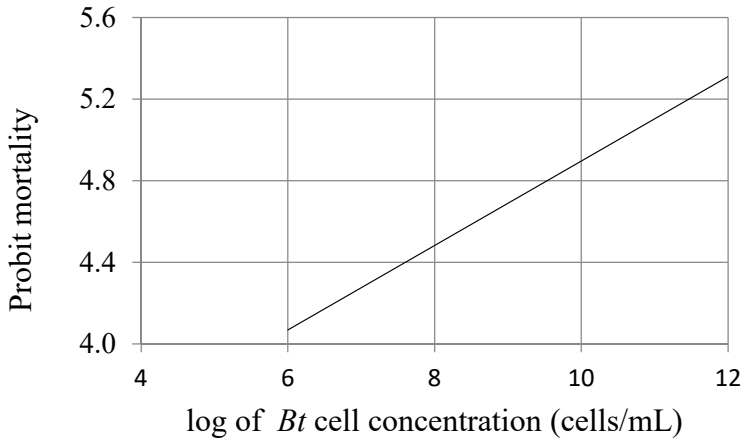
An object which is located on the point **B** is aimed to be a target of the reflected light. If the horizontal distance of the object in the point **B** to the mirror is 2.20 m, the vertical distance between **A** and **B** (H), and between **A** and the point of reflection (h) are 1.68 m and 0.430 m respectively, find the horizontal distance (x) between the light source device (**A**) and the mirror.

A. 0.381 m
B. 0.757 m
C. 1.04 m
D. 1.42 m

21. 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 by chemoreceptors and can fly toward their source. A chemoreceptor is a sensory receptor that detects chemical stimuli. The sensory organs responsible for this behavior are the comb like antennae. Each filament of an antennae is equipped with thousands of receptor cells that detect the sex attractant. The correct proposed hypothesis to account for the ability of the male moth to find the female: The chemoreceptor at the antenna of the male moth .....
    A. is only specific for detecting the chemical compound emitted from the female moth within certain distances. The male moth finds the female moth piloted by specific chemical compound which is emitted by the female moth.
    B. is not specific for detecting the chemical compound emitted from the female moth within certain distances.
    C. can detect all chemical compounds in the air but the male moth finds the female moth by chance.

D. can detect all chemical compounds in the air including specific chemical compound emitted from the female moth which guides the male to the female.

22. Pathogenicity of *Bacillus thuringiensis* (*Bt*) ORG1 isolate against instar 3 larvae of *Spodoptera litura* was determined by Probit Analysis. The LC50 is known as the concentration of bacterial cells that kills 50% (probit mortality = 5) of *Spodoptera litura* larvae. The probit analysis on Bt ORG1 isolate using the regression line $Y = 2.8279 + 0.2069X$ results in the LC50 during 24 hours = 3.15×1010 cell/mL. We tested another *Bt* isolate (*Bt* ORG2) for pathogenicity towards *Spodoptera litura* larvae and obtained a probit regression line with slope of 0.5245 and LC50 during 24 hours = 2.15×1010 cell/mL. Based on the value of LC50 and the slope of probit regression line, which *Bt* isolate is more pathogenic?

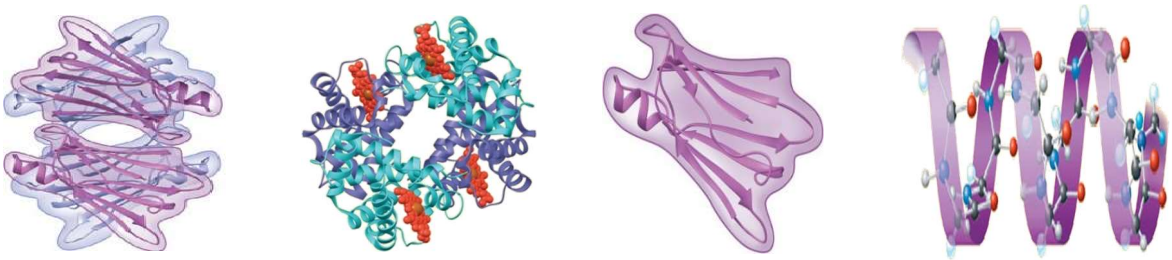


Probit regression line, $Y = 2.8279 + 0.2069X$, bioassay *Bt* isolate ORG 1 against 3th instar larvae of *Spodoptera litura*

A. *Bt* ORG1 isolate
B. *Bt* ORG2 isolate
C. *Bt* ORG1 is as pathogenic as *Bt* ORG2
D. Neither *Bt* isolate ORG1 nor *Bt* isolate ORG2 is pathogenic

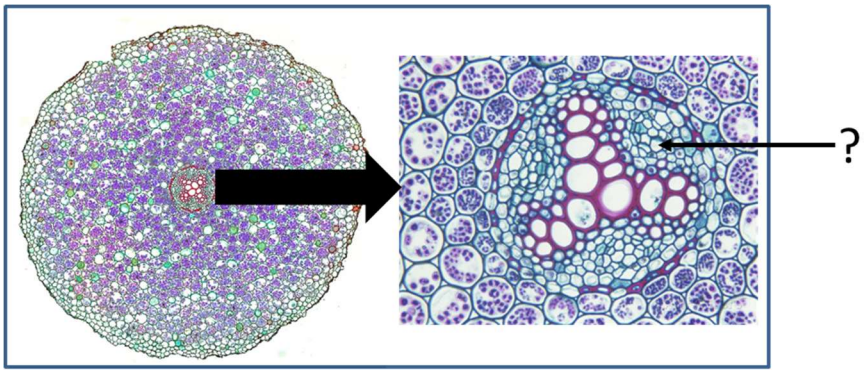
23. Which of the following statements is INCORRECT about a prokaryote? It has …..
A. nucleoid, a region where the cell's DNA is located (not enclosed by a membrane)
B. fimbriae-attachment structures on the surface of some prokaryotes
C. plasma membrane enclosing the cytoplasm
D. centrosome, a region where the cell's microtubules are initiated; contains a pair of centrioles

24. Hemoglobin, the oxygen-binding protein of red blood cells, is also a globular protein with quaternary structure. The quaternary structure of hemoglobin is figured out as four polypeptide sub-units, consisting of two α sub-units and two β sub-units. Both α and β sub-units primarily have α-helical secondary structure. Each sub-unit has a non-polypeptide component, called heme, in which an ion of iron binds oxygen. Which of the following figure represents the structure of hemoglobin?



A B C D

25. The following figure shows a cross section of the root of *Ranunculus* (buttercup) describing the organization of primary tissues in young roots. This root cross section represents basic pattern of root organization. What is the name of the root tissue indicated by the question mark?



Cross section of the root of *Ranunculus* (buttercup).

A. Phloem
B. Cortex
C. Xylem
D. Endodermis

26. Malaria is a disease caused by plasmodium. The plasmodium spreads from an individual to the others by a mosquito vector. A vector species of plasmodium-carrying mosquito lives in a forest together with two different species of monkeys, X and Y. Species X is immune to plasmodium, but species Y is not. That plasmodium-carrying mosquito is a food source for a particular bird in the forest. If all the birds were suddenly eliminated by hunters, which of the following statements would be an immediate observable consequence?
    A. Increased mortality (death rate) in species X
    B. Increased mortality in species Y
    C. Increased mortality in the plasmodium-carrying mosquitoes
    D. No increased mortality in both species X and Y

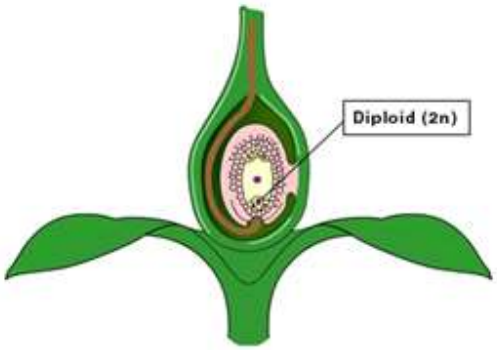
27. Certain species of acacia trees in Baluran National Park, East Java, Indonesia have hollow thorns inhabited (resided) by stinging ants which attack anything that touches the tree. The ants get nutrients produced by the acacia. This is an example of the interaction called…...
    A. Mutualism
    B. Parasitism
    C. Competitive exclusion
    D. Intraspecific competition

28. 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

    What is the frequency of allele M?
    A. 0.44
    B. 0.56
    C. 0.32
    D. 0.16

29. Sexual reproduction in plants and animals involve the union of two gametes to form a single cell called zygote. Gametes include the egg and sperm cells. Zygote is formed after the sperm fertilizes the egg, resulting in diploid chromosome. The zygote develops into ... .
(Hint: The following figure indicates fertilized egg)



A. Embryo
B. Endosperm
C. Carpel
D. Ovule

30. Photosynthesis consists of two processes, with each process involves multiple steps. These two photosynthesis processes are known as: (i) the light reaction as the first stage of photosynthesis that uses sunlight as an energy source absorbed by chlorophyll and (ii) the Calvin cycle as the second stage that can proceed without sunlight. Which of the following is INCORRECT statement about photosynthesis?
A. It is a combination of the light reactions and the Calvin cycle. In the chloroplast, the thylakoid membranes are the sites of the light reactions, whereas the Calvin cycle occurs in the stroma
B. The light reactions also generate ATP, using chemiosmosis to power the addition of a phosphate group to ADP, a process called photophosphorylation
C. The light reactions use solar energy to make ATP and NADPH, which supply chemical energy and reducing power, respectively, to the Calvin cycle
D. The Calvin cycle releases CO_2 from organic molecules, which are converted to sugar.

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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 = 7.5×10^{-3} mol

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

Volume of $CaCl_2$ = 7.5×10^{-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 100 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

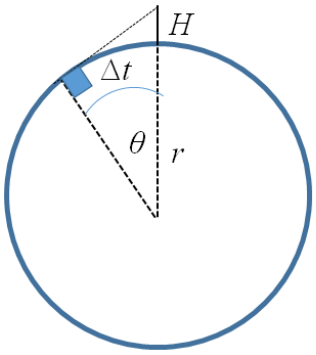
$$\rho_{Sand} V_{total} = \rho_{SiO_2} \frac{V_{total}}{1+e} \rightarrow \rho_{Sand} = \frac{\rho_{SiO_2}}{1+e}$$

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

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

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

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

$$\Delta L_{Br} + \Delta L_{St} = 5\times10^{-6}$$

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

$$5\times10^{-6} = \alpha_{Brt} L_{i=Br} \Delta T + \alpha_{St} L_{i=St} \Delta T \rightarrow \Delta T = \frac{5\times10^{-6}}{\alpha_{Brt} L_{i=Br} + \alpha_{St} L_{i=St}}$$

$$\Delta T = \frac{5\times10^{-6}}{19\times10^{-6}(0.03) + 11\times10^{-6}(0.01)} = 7.4$$

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

$$n\cos\theta = mg$$

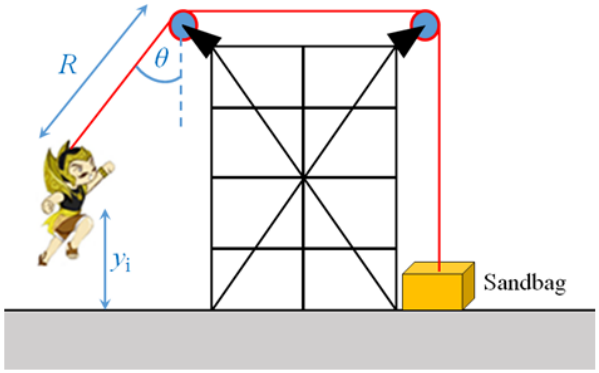
Dividing the previous equation with above equation, we find that

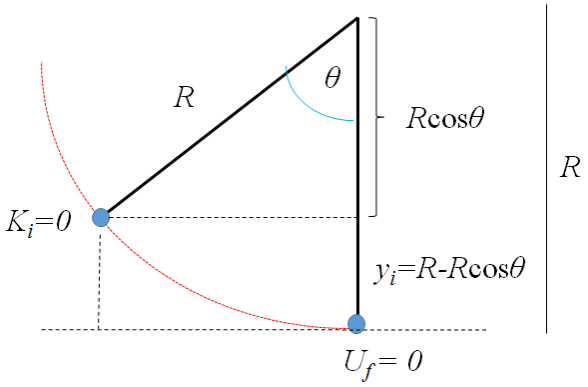
$$\tan\theta = \frac{v^2}{rg} \rightarrow \theta = \tan^{-1}\left(\frac{(13.4)^2}{50\times 9.8}\right) = 20.1^0$$

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

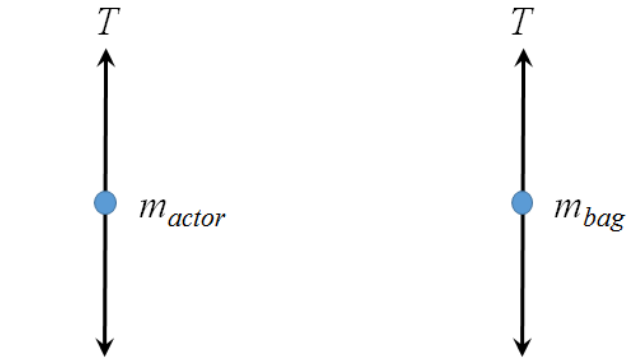
rest and that $U_f = 0$ because we define the configuration of the actor at the floor as having a gravitational potential energy of zero. Here, y_i is related to R and θ through the relation (see figure),

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

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,

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

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

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

And for the mass of sandbag, we have,

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

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

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:

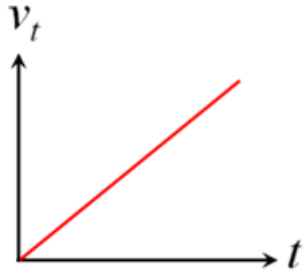
The force done by the magnetic field across to the wires is

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

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

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

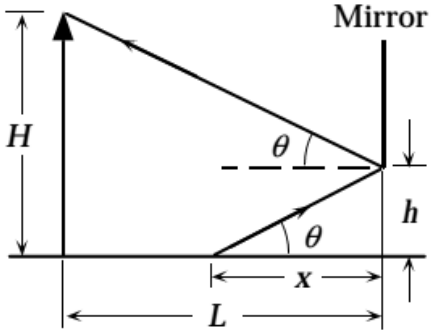
Therefore, v_t linearly depends on the time t, which is given in the following Figure,



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

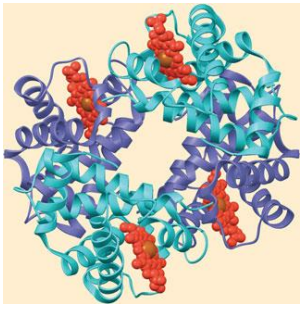
23. Answer: D

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

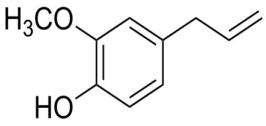
Explanation:

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

I. Essential Oil of Clove and Virgin Coconut Oil (VCO)

Eugenol is a phenylpropene, an allyl chain-substituted guaiacol (Figure I.1a). Eugenol is a member of the phenylpropanoids class of chemical compounds. It is a colourless to pale yellow oily liquid (Figure I.Ib) extracted from certain essential oils especially from clove oil, nutmeg, cinnamon, basil and bay leaf. It is present in concentrations of 80–90% in clove bud oil and 82–88 % in oil of clove leaf (Figure I.1c). Until modern times, cloves grew only on a few islands in the Maluku Islands (the Moluccas). Today, Indonesia, Madagascar, Zanzibar, Pakistan and Sri Lanka are world leader in clove output.

Eugenol is used in perfumes, flavorings, and essential oils. It is also used as a local antiseptic and anaesthetic. Eugenol can be combined with zinc oxide to form a material – known as zinc oxide eugenol (ZOE) – which has restorative and prosthodontic applications in dentistry. For example, zinc oxide eugenol is used for root canal sealing.



(a)

(b)

(c)

Figure I.1. Chemical structure of eugenol (a) clove oil (b), clove leaf and flower (c).

[QUESTIONS]

I.1 [**1.5 point**] Eugenol (Fig. 1a) is a monoprotic weak acid with Ka = 6.5 x 10^{-11}. If 1.64 g of eugenol (molar mass 164 g mol^{-1}) is dissolved in water to final volume of 1.00 L, the pH of the solution is .....

I.2 [**0.5 point**] Eugenol extracted from clove (*Syzygium aromaticum*) contains the elements carbon, hydrogen and oxygen combined in a ratio of 6.0 g of hydrogen, 60.0 g of carbon and 16.0 g of oxygen. If a given sample of eugenol was found to contain 128.0 g of oxygen, calculate the content (in grams) of hydrogen and carbon in the sample.

I.3 [**0.5 points**] A closed reaction flask containing eugenol ($C_{10}H_{12}O_2$) and ethyl bromide (C_2H_5Br) weighs 41.0 g. After reaction, an ether of eugenol ($C_{12}H_{16}O_2$) and hydrogen bromide (HBr) were formed in the reaction flask according to the following reaction.

$$C_{10}H_{12}O_2 + C_2H_5Br \rightarrow C_{12}H_{16}O_2 + HBr$$

Determine the mass of the reaction flask with its contents after the reaction.

I.4 [**1.0 point**] Eugenol is considered as a weak acid with Ka = 6.5 x 10^{-11}. If equal volumes of eugenol 0.02 M and 0.02 M HCl are mixed, calculate the pH of the mixture.

I.5 [**1.5 point**] A reaction of eugenol, $C_{10}H_{12}O_2$ and diethylsulphate, $(CH_3CH_2)_2SO_4$ to form ether of eugenol follows 1:1 stoichiometric ratio. If 82.0 g of eugenol is mixed for reaction with 115.5 g of diethylsulphate, by the end of the reaction, how many grams of the unreacted reactant remain (Ar C=12, S=32, O=16, H=1).

Virgin coconut oil (VCO) is obtained from fresh and mature kernel (12 months old from pollination) of coconut (*Cocos nucifera L.*) by mechanical or natural means with or without the application of heat, which does not lead to alteration of the nature of the oil. VCO has not undergone chemical refining, bleaching or deodorizing. It can be consumed in its natural state without the need for further processing. VCO consists mainly of medium chain triglycerides which are resistant to peroxidation. The fatty acids in VCO are distinct from animal fats which contain mainly of long chain saturated fatty acids. VCO is colorless, free of sediment with natural fresh coconut scent. It is free from rancid odor or taste.

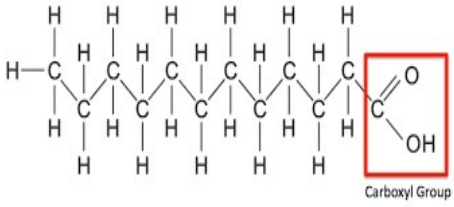


Fig. I.2 Chemical structure of lauric acid as the most abundant constituent of fatty acid in VCO

[QUESTIONS]

I.6 [**1.5 points**] For the purpose of determination of the acid value of coconut oil sample, a 2.0 g of sample is mixed with 30.0 mL of 0.250 M KOH solution. After a complete reaction, the excess of KOH is back-titrated with 0.250 M HCl and requires 10.0 mL. If the acid value is defined as the mass of KOH in mg required to neutralize 1.0 g of substance, calculate the acid value of the sample. (atomic mass K = 39, O =16, H = 1).

I.7 [**1.0 point**] The major constituents of saturated fatty acid in VCO are lauric acid ($C_{11}H_{23}COOH$), myristic acid ($C_{13}H_{27}COOH$) and palmitic acid ($C_{15}H_{31}COOH$). If these fatty acids are separated by TLC (thin layer chromatography) using a plate coated with polar adsorbent and non-polar solvent, arrange in order (from low to high) of retardation factor (R_f) of these fatty acids.

I.8 **[1.5 point]** The major component of fatty acids in VCO is lauric acid. 100 g of lauric acid ($C_{11}H_{23}COOH$) reacts with 160 mL of methanol (CH_3OH) to form methyl laurate ($C_{11}H_{23}COOCH_3$) according to the following reaction:

$$C_{11}H_{23}COOH + CH_3OH \rightleftharpoons C_{11}H_{23}COOCH_3 + H_2O$$

The equilibrium constant (K_{eq}) of the reaction is 0.9 (H_2O should be included in the equilibrium constant). Calculate the mass of methyl laurate formed
(Atomic mass C=12, H=1, O=16; methanol density = 0.8 g/mL)

I.9 [**1.0 points**] Polyvinyl chloride (PVC) is one of the most used plastics for containers of various liquids including VCO. The raw material for the preparation of PVC, C_2H_3Cl is prepared based on the following reaction: $C_2H_2 + HCl \rightarrow C_2H_3Cl$. If 26.0 g of C_2H_2 is mixed with 40.0 g of HCl, calculate the weight (in grams) of C_2H_3Cl that will be formed after the reaction is complete. (Ar H = 1, C=12 and Cl = 35.5).

II. Physics of Underwater Diving

Diving is a kind of underwater sport, especially under the sea to enjoy its beauty. There are some beautiful diving spots in Bali such as USS Liberty Wreck in Tulamben, Gili Tepekong, Nusa Lembongan etc. Since the diving could be dangerous due to the underwater environment, never dive alone. You have to dive with a dive trainer.

The sport of diving can be divided into two different classes,

1) SCUBA diving, and
2) Free diving.

SCUBA diving is a mode of underwater diving in which a diver uses a *self-contained underwater breathing apparatus* (SCUBA) to breathe underwater. The apparatus is a gas (air) tank mounted in the diver body. See Fig. II.1(a).

Meanwhile, free diving is a mode of diving without using any complex apparatus needed in SCUBA. Before submerge underwater, a free diver in the surface takes a long breath and holds his/her breathe when dives underwater. See Fig. II.1(b).

(a) (b)

Figure II.1. (a) a SCUBA diver uses an air tank mounted in the diver body.
(Courtesy: https://en.wikipedia.org/wiki/Scuba_diving)
(b) free diver without using an air tank (Courtesy: http://www.freediveutila.com).

The main difference between SCUBA diving and free diving is written as follows:

- For SCUBA diving, one must breath normally, similarly in the surface, and never hold his/her breath when dive under water. A SCUBA diver inhales air from the tank and exhales air into the water.
- For free diving, one must hold his/her breath, and never exhales underwater.

In addition, however, both type of divers use some extra equipments for their comfort during diving underwater such as fins in their legs for efficient movement and a mask covering eyes and nose.

For all situations, all gases in air, human lungs or scuba tube can be regarded as an ideal gas. The gas ideal equation can be written as

$$pV = nRT$$

where p = pressure, V = volume, n = number of mol, R = universal gas constant = 8.31 J/(K mol), and T = temperature.

When a diver descends to a greater depth, the water pressure will increase. In order to avoid the danger inside the body, the air pressure inside the body (such as lungs and sinuses) must be the same with the pressure of the surrounding water. Here the diver should make the so-called "equalization" technique to make the pressure inside the ear drums equals the total outside pressure.

Some physical constants are as follows.

- acceleration of gravity $g = 9.80$ m/s^2
- density of seawater $\rho_{sw} = 1.03 \times 10^3$ kg/m^3
- 1.00 atm = 1.01×10^5 N/m^2 = 1.01×10^5 Pa

Additional information: Answer all questions. Write down all equations used in the Answer Sheets.

[QUESTIONS]

II.1 **[1.0 points]** If the atmosphere pressure at the sea level is $p_{atm} = 1.00$ atm, find the total pressure at the depth of 20.0 meter under the sea surface.

II.2 **[2.0 points]** A special valve in SCUBA tank automatically adjusts the pressure of air coming from the SCUBA tank to ensure that the air pressure equals the total pressure at all times. The tank volume is 1.50×10^{-2} m^3 filled with the compressed air at an absolute pressure of 150 atm. Let us assume that the diver consumes air about the rate r of 20.0 L per minute. If the diver constantly dives under the sea water at the depth of 10.0 m, calculate the maximum time (in minutes) of his/her diving. Assume that the tank temperature remains constant during diving.

II.3 **[1.5 points]** Due to long duration under the sea and the temperature difference between the body and the sea (which is colder than the body), a SCUBA diver should use a special SCUBA suit for preventing heat conduction, whose thermal quality is indicated by **R**-value. The **R**-value is defined as the reciprocal of the amount of heat power per

area of material per degree temperature difference between inside and outside. For this case, the inside and the outside correspond to the body and the sea water, respectively.

No	Some international units
1	$\frac{\mathrm{J\,m^2\,K}}{\mathrm{s}}$
2	$\frac{\mathrm{m^2\,K\,s}}{\mathrm{J}}$
3	$\frac{\mathrm{s}}{\mathrm{J\,m^2\,K}}$
4	$\frac{\mathrm{J}}{\mathrm{m^2\,K\,s}}$

II.3.a. From the above table, choose the correct international unit for **R**-value.

Some **R**-value of materials for scuba suit in international unit are given in the table below. The best material for SCUBA suit is the material in which the total transferred heat from the body to the sea as minimum as possible.

No	Name of material (abbreviated)	R-value
1	A	1.0
2	C	3.7
3	G	4.5
4	N	5.5

II.3.b From the above data, choose the best material for scuba suit?

II.4 **[1.0 points]** If a free diver descends too quickly into the sea, the internal pressure on each ear drum remains at atmospheric pressure, while the external pressure increases due to the increased water depth. At sufficient depths, the difference between the external and internal pressures can rupture the ear drums. The ear drums can be ruptured when the pressure difference is as little as 35.0 kPa. What is the depth at which this pressure difference occurs?

II.5 **[1.0 points]** Before submerging under the sea water, a free diver takes a final long breath and then holds the breath. Let us assume that the volume of the diver's lungs after holding the breath is 6.00 L. Calculate his/her lungs volume at the depth of 30.0 m using the assumption that the diver makes a good equalization so that the internal pressure in the lungs equals to the total external pressure. Assume that the temperature inside the lungs is constant, and no exhaled air from the diver.

II.6 **[2.0 points]** A diver releases a stone from the sea surface with zero initial velocity. The stone falls under the water and feels the drag force F_d opposite to its direction written as

$$F_d = -bv$$

where b is a positive constant and v is the stone velocity (positive downward). Later, the diver finds that the terminal velocity of the stone is $v_t = 8.00$ m/s. If the mass and the density of the stone are respectively 7.50×10^{-2} kg and 2.60×10^3 kg/m^3, find the value of b.

II.7 **[1.5 points]** A diver submerges under water and notices that the sunset almost occurs. The refractive indices of the water and the air are 1.33 and 1.00, respectively. What is the maximum angle between the normal and the refracted sunlight that the diver sees?

III. Komodo Dragon

The Komodo dragon (*Varanus komodoensis*) is the largest species of lizard found in the Indonesian islands of Komodo, Rinca, Gili Motang and Padar. It is a member of the Family of Varanidae. An average weight and body length of adult male are 85 kg and 2.59 m, respectively, whereas an average weight and body length of adult female are 70.5 kg and 2.29 m, respectively. Its unusual huge size has been attributed to island gigantism, since no other carnivorous animals live in the niche where they live. Its life span is from 20 up to 30 years. The population is relatively stable on the bigger islands (Komodo and Rinca), but decreases on the smaller islands (Padar and Gili Motang), because of diminishing prey availability. In Padar, the population of Komodo dragon became extinct in 1975. It is assumed that the Komodo dragon died out after a strong decline of the population of large ungulate prey by poaching. Total population of Komodo dragon in 2013 in the wild was about 3,222. Its population reduced to 3,092 in 2014 and 3,014 in 2015.

Figure of the Komodo dragon (Bradford A. 2014. Live Science Contributor.
Credit: Sergey Uryadnikov / Shutterstock)

According to the International Union for Conservation of Nature (IUCN), Komodo dragon is one that has been categorized as a vulnerable species, included in the Red List. It is likely to become endangered species when the circumstances for reproduction do not improve. Loss of habitat may cause an extinction of the species. In order to conserve and protect the Komodo dragon population, several islands around Flores Island, such as Komodo, Rinca, and Padar Islands are developed as the Komodo National park for their natural habitats.

Komodo dragons belong to ectothermic and diurnal animals. The natural habitat of Komodo dragons typically is hot and dry places, humid, open grassy lowland, savanna, and

tropical rain forests at low elevations, and also on the volcanic slopes. They require plenty of trees for the protection of their offspring.

Breeding season of Komodo dragon occurs between May and August, and spawn on September. The Komodo dragon females dig holes in the ground to accommodate about 20 eggs, which laid later and recapped with litter. Eggs of Komodo dragon hatched 7 months after it has been laid and the offspring become mature around 9 years later. The offspring of Komodo dragon will stay in a safe place in a large hole on the tree. The offspring ambush invertebrate such as grasshoppers and beetle for their prey, while the mature of Komodo-dragon's prey mainly are life deer, wild buffalo and also considerable amounts of carrion.

When the komodo dragon bites its prey, it secretes an anticoagulant through two venom glands located in the lower jaw with ducts coming out of its teeth. The anticoagulant is an anti-blood clotting compound that causes their prey bleeds and dies.

[QUESTION]

Answer the questions below by choosing the right answer(s) listed in the box provided, except for the questions number III.4 and III.7. Cross the answer(s) on the space provided on the answer sheet (more than one answer may be correct).

III.1 [**1.0 point**] The Komodo dragon (*Varanus komodoensis*) is an ectothermic/poikilothermic/cold-blooded animal. Which statement(s) apply to the thermal regulation of the komodo dragon?

III.2 [**1.0 point**] There are two glands in the lower jaw of Komodo dragon which secrete an anticoagulant, when the Komodo dragon bites its prey. Select the agent with the correct explanation that acts as an anticoagulant.

III.3 [**1.0 points**] When a Komodo dragon kills and eats a deer, what is the trophic level and the role in the ecosystem of this Komodo dragon?

III.4 [**2.0 points**] Consider the Komodo dragon population size in the year 2013 as 100% in the figure given below. Calculate the percentage population in 2014 and 2015 relative to 2013, and construct a histogram using the calculated data.

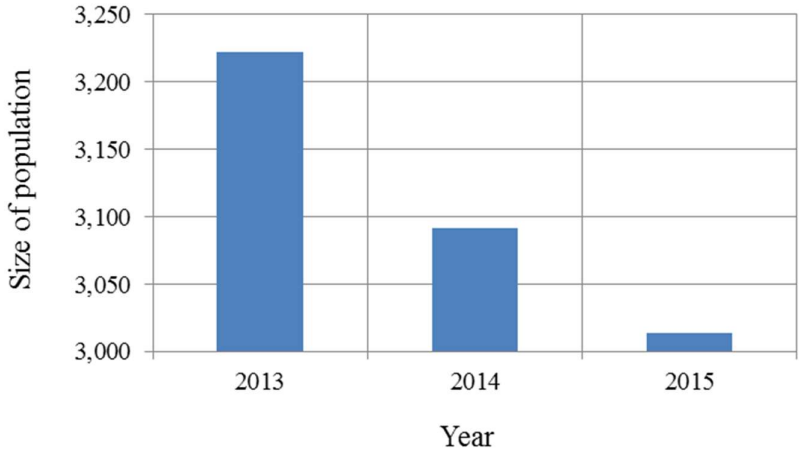


Figure of the Komodo dragon population from 2013 to 2015

III.5 [**1.0 point**] Give the reason(s) why the Komodo dragon population is gradually decreased from 2013 to 2015.

III.6 [**2.0 points**] The figure shows different parts of the alimentary canals of vertebrate animals. The alimentary canal of the komodo dragon can be predicted, based on what it eats. Construct the alimentary canal of the komodo dragon, from food to feces, by selecting the right parts and putting the corresponding numbers in the right order.

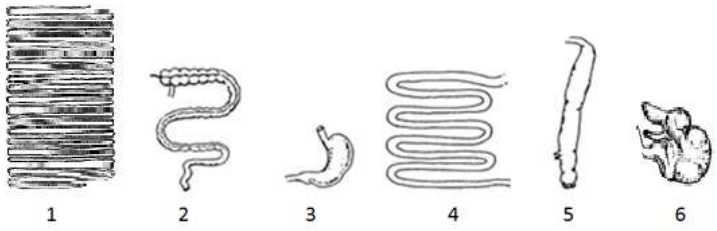


Figure of different parts of the alimentary canals of vertebrate animals

III.7 [2.0 points] In Komodo dragons, the sex of the offspring is determined by the ZW sex chromosome system. Males have two Z chromosomes, while females have a Z and a W. Suppose there is a gene located only on the Z chromosome, which determines the production of an anti-coagulation protein. A Z-chromosome carrying the functional gene is noted as Z^N and a Z-chromosome with a mutated non-functional gene is designated Z^n, which is the recessive allele.

The following pedigree of Komodo dragons represents the occurrence of this mutant protein. For all dragons, except individuals 2.4 and 3.2, determine their set of sex chromosomes and mark the one correct genotype with a cross in the table on the Answer Sheet.

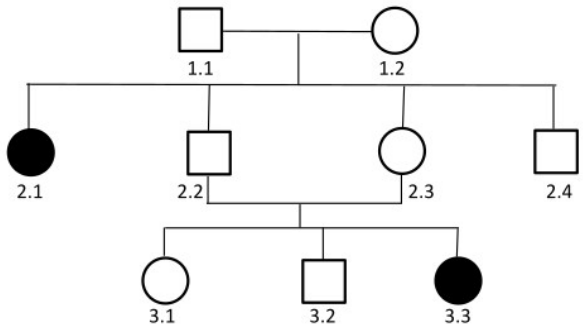


Figure of pedigree of Komodo dragons

Table of set of sex chromosomes of Komodo dragon:

Individual dragon	Z^N Z^N	Z^N Z^n	Z^n Z^n	Z^N W	Z^n W
1.1					
1.2					
2.1					
2.2					
2.3					
3.1					
3.3					

THE ANSWERS BOX

A.	An animal temperature does not fluctuate with the environment
B.	Predator
C.	First level consumer
D.	Animals that use only behavioral adaptation to manipulate their temperature
E.	Viviparous
F.	Animals that are hot when their environment is hot and cold when their environment is cold
G.	Third trophic level
H.	3, 4, 5
I.	Heparin, which acts by inactivating thrombin and preventing the conversion of fibrinogen to fibrin
J.	Fourth trophic level
K.	6, 1, 5
L.	Animals that can maintain its body temperature by generating their own heat when they are in a cooler environment, and by cooling themselves when they are in a hotter environment.
M.	Vitamin K, which activates prothrombin into thrombin and thrombin activates fibrinogen to form fibrin
N.	Warfarin, which stimulates the effects of vitamin K which are needed to make some clotting factors
O.	Animals that are hot when their environment is cold and hot when their environment is hot
P.	Decreasing the population of komodo-dragon's prey
Q.	Loss of Komodo dragon habitat
R.	Vitamin K, which acts by inactivating thrombin and several other clotting blood factors that are required for a cloth to form
S.	130% and 78%
T.	Carnivore
U.	4.03% and 2.40%
V.	Herbivore
W.	The Komodo dragons have a lot of predators

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--- ANSWER SHEET ---

DECEMBER, 6th 2016

FILL IN THE FOLLOWING INFORMATION

FIRST NAME	
MIDDLE NAME	
LAST NAME	
COUNTRY	
CODE	
SIGNATURE	

PROBLEM I

I.1 The pH of the solution is...

Points: 1.5	Answer :

I.2 Calculate the content (in grams) of hydrogen and carbon in the sample.

Points: 0.5	Answer : Hydrogen = Carbon =

I.3 Determine the mass of the reaction flask with its contents after the reaction.

Points: 0.5	Answer : Mass of the reaction flask with its contents after the reaction

I.4 Calculate the pH of the mixture

Points: 1.0	Answer : pH of the mixture =

I.5 How many grams of the unreacted reactant remain

Points: 1.5	Answer :

I.6 Calculate the acid value of sample

Points: 1.5	Answer : Acid value of sample =

I.7 Fill in the box provided with numbers 1, 2, or 3 to show the order that you choose of the retardation factor (R_f) (from low to high).

Points: 1.0		
		Lauric acid
		Myristic acid
		Palmitic acid

I.8 Calculate the mass of methyl laurate formed

Points: 1.5	Answer : Calculate the mass of methyl laurate formed =

I.9 Calculate the weight (in grams) of C_2H_3Cl that will be formed after the reaction is complete

Points: 1.0	Answer : The weight of C_2H_3Cl =

---------- DO NOT WRITE BELOW ----------

Total points for Problem I	

PROBLEM II

II.1 Find the total pressure at the depth of 20.0 meter under the sea surface.

Points: 1.0	Answer:

II.2 Calculate the maximum time (in minutes) of his/her diving.

Points: 2.0	Answer:

II.3a. [0.5] Choose the correct international unit for **R**-value.

No	Some international units
1	$\frac{\mathrm{J\,m^2\,K}}{\mathrm{s}}$
2	$\frac{\mathrm{m^2\,K\,s}}{\mathrm{J}}$
3	$\frac{\mathrm{s}}{\mathrm{J\,m^2\,K}}$
4	$\frac{\mathrm{J}}{\mathrm{m^2\,K\,s}}$

II.3b. [1.0] Choose the best material for SCUBA suit.

No	Name of material (abbreviated)	R-value
1	A	1.0
2	C	3.7
3	G	4.5
4	N	5.5

II.4 What is the depth at which this pressure difference occurs?

Points: 1.0	Answer:

II.5 Calculate his/her volume of the lungs at the depth of 30.0 m.

Points: 1.0	Answer:

II.6 Find the value of *b*.

Points: 2.0	Answer :

II.7 What is the maximum angle between the refracted sunlight and the normal that the diver sees?

Points: 1.5	Answer :

---------- DO NOT WRITE BELOW ----------

Total points for Problem II	

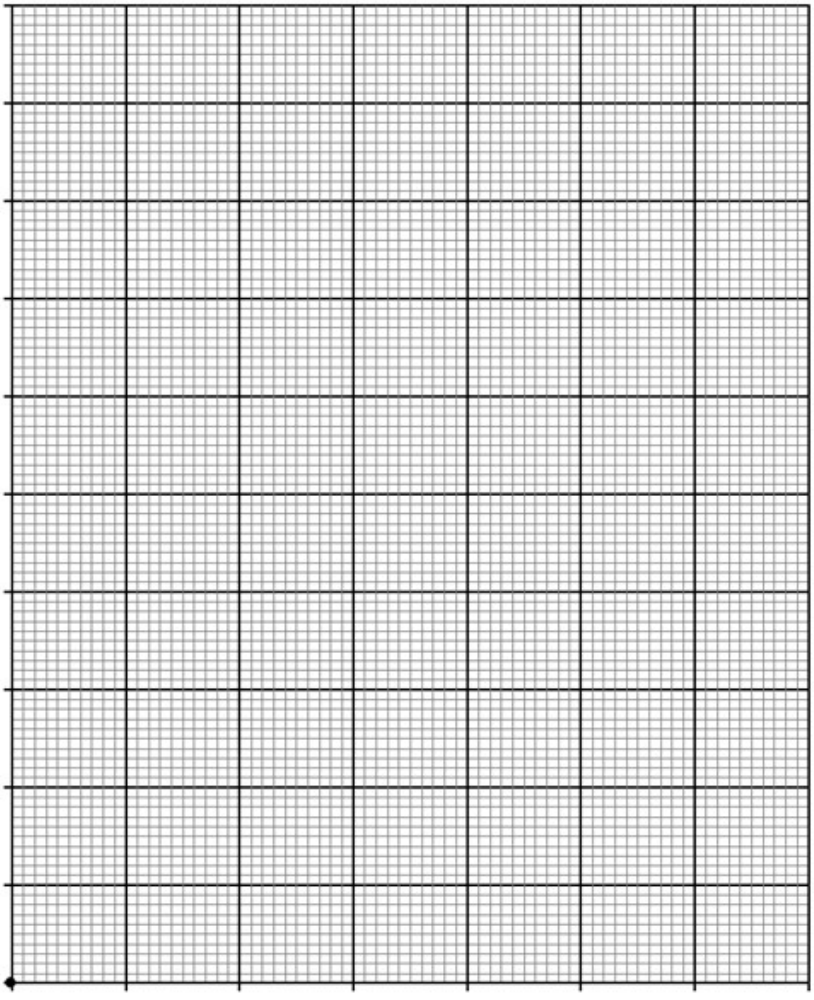
PROBLEM III

Cross the correct answer on the box provided. Look for the letter that you think is the correct answer to the questions and then provide a cross on that letter below the number. *Example*: if you think that the correct answer for problem III.1 is V, then you cross the letter V below III.1.

	Question:				
	III.1	III.2	III.3	III.5	III.6
ANSWERS	A	A	A	A	A
	B	B	B	B	B
	C	C	C	C	C
	D	D	D	D	D
	E	E	E	E	E
	F	F	F	F	F
	G	G	G	G	G
	H	H	H	H	H
	I	I	I	I	I
	J	J	J	J	J
	K	K	K	K	K
	L	L	L	L	L
	N	N	N	N	N
	O	O	O	O	O
	P	P	P	P	P
	Q	Q	Q	Q	Q
	R	R	R	R	R
	S	S	S	S	S
	T	T	T	T	T
	U	U	U	U	U
	V	V	V	V	V
	W	W	W	W	W
	1.0	1.0	1.0	1.0	2.0

III.4 Point: 2.0

Calculate the percentage population in 2014 and 2015 relative to 2013, and construct a histogram using the calculated data.



III.7 [2.0 points] Determine the set of sex chromosomes of the Komodo dragon and mark the one correct genotype with a cross in the following table

Individual dragon	$Z^N Z^N$	$Z^N Z^n$	$Z^n Z^n$	$Z^N W$	$Z^n W$
1.1					
1.2					
2.1					
2.2					
2.3					
3.1					
3.3					

---------- DO NOT WRITE BELOW ----------

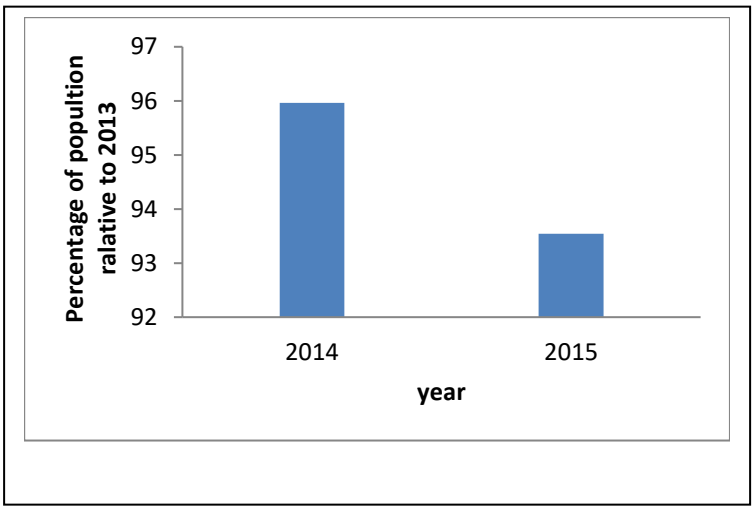
Total points for Problem III	

FINAL ANSWER FOR BIOLOGY SOLUTION : 6 Desember 2016

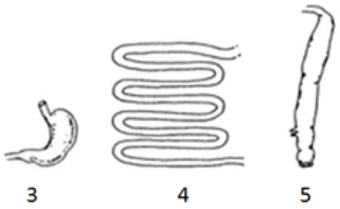
1.	Answer : D and F
Point: 1	Explanation : D. Animals that use behavioral adaptation to manipulate temperature F. Ectothermic animal: Animals referred to cold blooded, they are hot when their environment is hot and cold when their environment is cold

2.	Answer : I
Point: 1	Explanation : Heparin, acts to inactivate thrombin and prevent the conversion of fibrinogen to fibrin

3.	Answer : B and G
Point: 1	Explanation : B: Predator: T: Carnivore G: Third tropic level → compulsory Mature komodo dragon's prey mainly are life deer and wild buffalo G and B = 1.0 point G and T = 1.0 point G, B and T = 1.0 G, other than B and T = 0.5 point No G, with either B and T = 0.5 point

4.	
Point: 2	Percentage 2013: 100% 2014 : 95.97% (point 0.5) 2015 : 93.54% (point 0.5)  Figure 1. Komodo Population Total point of construction histogram is 1. 5 item answers @ 0.2 point: Histogram title, x-axis title (year), y-axis title (percentage), year of observation (2014, 2015), the graph must be a histogram. Option: 1. The graph must be a histogram, others are incorrect 2. The keyword for title of the histogram is Komodo Population 3. X-axis title keyword: year 4. Y-axis title keyword: percentage or %. As long as consistent in writing style, any number or scale is allowed. 5. 2014, 2015. Extra 2013 is allowed.

5.	Answer : P and Q
Point: 1	Explanation : (P.) Decreasing the population of komodo-dragon's prey And (Q) lost of komodo Habitat

6.	Answer : H (3,4,5)
Point: 2	Explanation :  A pure carnivore has a simple tube for an intestinal system. That tube has a bulge at the beginning of it that serves as a stomach. The tube then winds and twists inside the abdomen of the carnivore. **Cecum:** The cecum in a carnivore digestive system is a tiny useless appendage

7.	Answer : @ 0.286
Point: 2 @ 0.286	1.1 : $Z^{N}Z^{n}$ 1.2 : $Z^{N}W$ 2.1 : $Z^{n}W$ 2.2 : $Z^{N}Z^{n}$ 2.3 : $Z^{N}W$ 3.1 : $Z^{N}W$ 3.3 : $Z^{n}W$

ATTENTION

This table is used for question number: III. 1,III. 3,III. 5

Number of expected correct answer(s)	Number of answer(s)	Number of correct answer(s)	Point
2	2	2	1
	2	1	0.5
	3	1	0.5
	3	2	0.5
	4 or more	Not to be considered	0

Question contain only one correct answer (III.2)

Number of expected correct answer(s)	Number of answer(s)	Number of correct answer(s)	Point
1	1	1	1
	2	1	0

Question contain only one correct answer (III.6)

Number of expected correct answer(s)	Number of answer(s)	Number of correct answer(s)	Point
1	1	1	2
	2	1	0

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SOLUTIONS AND MARKING SCHEME

Problem I. Chemistry

Question	Content	Points	Total
I.1	As a weak acid (HA), eugenol is partly dissociate in water to give H_3O^+ and A^- ions, according to the following equilibrium reaction: $HA + H_2O \rightleftharpoons H_3O^+ + A^-$ The dissociation constant is given by $Ka = [H_3O^+][A^-]/[HA]$; From the equation, it is understood that $[H_3O^+] = [A^-]$ 1.64 g of eugenol = 1.64 g / 164 $g.mol^{-1}$ = 0.01 mol Since it is dissolved in 1 L solution, the concentration of eugenol = 0.01 M	0.5	1.5
	Therefore $[H_3O^+]^2 = K_a[HA]$ or $[H_3O^+] = \sqrt{(Ka[HA])} = \sqrt{(6.5 \times 10^{-11} \times 0.01)} = 8.06 \times 10^{-7}$; since $pH = -\log[H_3O^+]$, then **pH = 6.1**	1.0	
I.2	Hydrogen = 6/16 x 128 g = **48 g**	0.25	0.5
	Carbon = 60/16 x 128 g = **480 g**	0.25	
I.3	The mass of the product (ethyl eugenolate and hydrogen bromide) is equal to the sum of the masses of the eugenol and ethyl bromide consumed. The mass of materials not involved in the reaction are unchanged. Therefore, the total mass after reaction is **41.0 g**		0.5
I.4	As a weak acid (HA), eugenol is partly dissociate in water to give H_3O^+ and A^- ions, according to the following equilibrium reaction: $HA + H_2O \rightleftharpoons H_3O^+ + A^-$ The dissociation constant is given by $Ka = [H_3O^+][A^-]/[HA]$; From the equation, it is understood that $[H_3O^+] = [A^-]$ Therefore $[H_3O^+]^2 = K_a[HA]$ or $[H_3O^+]$ from eugenol = $\sqrt{(Ka[HA])} = \sqrt{(6.5 \times 10^{-11} \times 0.02/2)} = 8.06 \times 10^{-6}$ As a strong acid HCl completely dissociate in water to give $[H_3O^+]$ = 0.02/2 = 0.01 M Hence the total $[H_3O^+]$ in the solution = $[H_3O^+]_{eugenol} + [H_3O^+]_{HCl} = (0.01 + 8.06 \times 10^{-6}) \approx 0.01$ M Hence, the pH of the solution = $-\log [H_3O^+]$ = **$-\log 0.01 = 2$**		1.0
I.5	Since the stoichiometric of the reaction is 1:1, it means that one mole of eugenol requires 1 mole of diethyl sulphate. Mr of Eugenol = (10 x 12) + (12 x1) + (2 x 16) = 164 $g.mol^{-1}$ Mr of diethyl sulphate = (4 x 12) + (2 x 5) + (1 x 32) + (4 x 16) = 154 $g.mol^{-1}$ Hence 82.0 g of eugenol = 82 g/164 g. mol^{-1} = 0.5 mol, and 115.5 g of diethyl sulphate = 115.5 g/154 $g.mol^{-1}$ = 0.75 mol Therefore, the remaing reactant is 0,25 mole of **diethyl sulphate** = 0,25 mol x 154 g/mole = **38.5 g of diethyl sulphate.**	0.5 0.5 0.5	1.5

I.6	Initial KOH= 30 mL x 0.25 mmol/mL = 7.5 mmol	0.3	1.5
	The excess of KOH= 10 mL x 0.25 mmol/mL = 2.5 mmol	0.3	
	KOH consumed for determination of acid value: (7.5-2.5) mmol = 5 mmol	0.3	
	mg KOH consumed for 2 g of sample = 5 mmol x 56 mg/mmol = 280 mg	0.3	
	Acid Value = 280 mg/2g = 140 mg KOH/g sample	0.3	
I.7	The polarity of carboxylic acid increase with the decrease in the number of carbon, so the lauric acid with 12 carbon is the most polar followed by myristic and palmitic acids. Since the stationary phase is a polar materials and the solvent is non-polar, the lauric acid will have retardation factor (R_f) lowest and followed by myristic and palmitic acids, or (1) R_f lauric acid < (2) R_f myristic acid < (3) R_f palmitic acid		1.0
I.8 (1.5)	Mr of $C_{11}H_{23}COOH$ = (12 x 12) + (24 x 1) + (2 x 16) = 200 $g.mol^{-1}$ Mr of CH_3OH = (1 x 12) + (4 x 1) + (1 x 16) = 32 $g.mol^{-1}$ Mass of CH_3OH = 160 mL x 0.8 $g.mL^{-1}$ = 128 g Mole of CH_3OH = 128 g/32 $g.mol^{-1}$ = 4 mol Mole of $C_{11}H_{23}COOH$ = 100 g/200 $g.mol^{-1}$ = 0.5 mol Suppose the ester formed = x mol, the H_2O produces x mol, then The remaining lauric acid = (0.5-x) mol and the remaining methanol = (4.0-x) K_{eq} =x.x/(0.5-x)(4.0-x) → $0.1x^2 + 4.05\ x - 1.8 = 0$ By using abc formula, we have x = 0.45 mol	1.0	1.5
	Hence, the ester formed = 0.45 mol x 214 $g.mol^{-1}$ = **96.3** g	0.5	
I.9	26 g C_2H_2 = 26 g : 26 mol . g^{-1} = 1.0 mol	0.5	1.0
	40 g HCl = 40 g : 36.5 mol . g^{-1} = 1.1 mol		
	As mol C_2H_2 is smaller than mol HCl, so the formed C_2H_3Cl will be equal to the mol of C_2H_2, i.e. 1.0 mol or equivalent to **62.5 g**	0.5	
			10

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SOLUTIONS AND MARKING SCHEME

Problem II. Physics

Question	Content	Points	Total
II.1	Correct formula $p_{total} = p_{atm} + \rho gh$	0.5	1.0
	Correct total pressure = 3.03×10^5 N/m^2 = 3.03×10^5 Pa = 3.00 atm. $3.00 \le p_{total} \le 3.06 \times 10^5$ N/m^2 or $2.97 \le p_{total} \le 3.03$ atm is acceptable	0.5	
	Incorrect/incomplete solutions:		
	Correct value without unit	0.3	
	Formula only $p_{total} = \rho gh$	0.2	
	Other formulas	0.0	
	Total pressure $2.70 \le p_{total} < 2.97$ atm or $3.03 < p_{total} \le 3.30$ atm	0.2	
	Other values	0.0	
II.2	Correct formula total time $t = \dfrac{\text{Total volume of air consumed}}{r} = \dfrac{V_f - V_i}{r}$	0.4	2.0
	Correct Boyle law $P_iV_i = P_fV_f$ or $V_f = \dfrac{P_iV_i}{P_f}$	0.4	
	Correct formula for total pressure $p_f = p_{atm} + \rho_{sw}gh$	0.4	
	Correct formula for total time $t = \dfrac{V_i(p_i - (p_{atm} + \rho_{sw}gh))}{r(p_{atm} + \rho_{sw}gh)}$	0.4	
	Correct value of total time t = 55.5 minute. The total time $54 \le t \le 57$ minutes is acceptable	0.4	
	Incorrect/incomplete solutions:		
	Total volume of air consumed = V_f	0.2	
	Total pressure $P_f = \rho_{sw}gh$	0.2	
	The total time is 50 minutes < $t \le 54$ minutes or 57 minutes < $t \le 60$ minutes	0.2	
	Other total time	0.0	
II.3	Correct international unit: 1/(watts /(m^{2}K)) = m^{2}K/W = m^{2}K/(J/s) = m^{2}Ks/J	0.5	1.5
	Correct the best material: N	1.0	
	Incorrect/incomplete solutions:		
	Incorrect SI unit	0.0	
	Incorrect the best material	0.0	
II.4	Correct formula: $h = \Delta p/\rho g$	0.5	1.0
	Correct value of depth: h = 3.47 m The range of depth $3.41 \le h \le 3.55$ m is acceptable	0.5	
	Incorrect/incomplete solutions:		
	Correct depth without unit	0.3	
	Incorrect formula	0.0	
	The depth is 3.15 m $\le h <$ 3.41 m or 3.55 m < $h \le$ 3.80 m	0.2	
	Other value of depth	0.0	

Question	Content	Points	Total
II.5	Pressure at the depth 30 m = 4 atm	0.3	1.0
	Correct formula: Boyle law	0.3	
	Correct value of volume V = 1.50 L The volume 1.45 L ≤ V ≤ 1.55 L is acceptable	0.4	
	Incorrect/incomplete solutions:		
	Correct volume without unit	0.2	
	Incorrect formula	0.0	
	The volume is 1.35 L ≤ V < 1.45 L or 1.55 L < V ≤ 1.65 L	0.2	
	Other volume	0.0	
II.6	Correct equation of force with or without force diagram	1.0	2.0
	Correct formula of $b = \frac{m_s g}{v_t}\frac{\rho_s - \rho_{sw}}{\rho_s}$	0.5	
	Correct value of $b = 5.55\times10^{-2}$ kg/s The value b $5.45 \le b \le 5.65\times10^{-3}$ kg/s is acceptable	0.5	
	Incorrect/incomplete solutions:		
	Correct b without unit	0.3	
	All forces are written, however wrong signs	0.5	
	Not all forces are written	0.0	
	Incorrect formula of b	0.0	
	The value of b $5.35 \le b < 5.45\times10^{-2}$ kg/s or $5.65 < b \le 5.75\times10^{-2}$ kg/s	0.2	
	Other value of b	0.0	
II.7	Correct formula: Snell law	0.5	1.5
	Correct formula of angle in sea water	0.5	
	Correct value of angle = 48.8°. The angle rounded to 49° or 48.3° ≤ θ ≤ 49° is acceptable.	0.5	
	Incorrect/incomplete solutions:		
	Incorrect Snell law	0.0	
	Incorrect formula of angle in water	0.0	
	The angle 47.0° ≤ θ < 48.3°	0.2	
	Other angles	0.0	
	Total points for Problem II		10

Notes:

- no double penalty
- this marking scheme is a guidance for all physics juries.
- other ways for physics formula derivations are acceptable, if physically correct.

INTRODUCTION

The following experiment deals with the isolation process of an essential oil from seeds by means of hydro-distillation technique. Hydro-distillation is a method of distillation employing boiling water to extract essential oils from certain raw materials. Hydro-distillation is so far becoming the cheapest and most general distillation method employed in the isolation of essential oils from plant materials.

In practice, the raw material is soaked in water, then the mixture is heated to boiling and the distillates are collected after being cooled in the condenser. Due to polarity difference between isolated essential oils and water, the essential oils normally do not mix with water and accordingly separate from the water layer. Separation of the oils by means of an external separating funnel would result in the production of crude essential oils. Further purification technique is often required to obtain pure components present in the isolated essential oils.

The plant material used in this experiment is the fruit and the seed of *Myristica fragrans* Houtt, an evergreen tree, native of the East Moluccas, Indonesia. The seed of plant is known as 'nutmeg' and attached with arillus (specialized covering of a seed that partly or completely covered the seed), and is used for flavoring food and medicinal purposes. In this experiment, the participants will perform the following experiments related to "nutmeg and hydro-distillation".

In this competition, you will perform the experimental procedure that will be used to answer all the questions in Physics, Biology and Chemistry. Read each step of the procedure thoroughly and carefully.

The hydro-distillation apparatus consists of:

1. Electric stove
2. Three-necks cylindrical boiling flask
3. Glass Allihn Condenser, Ball Shape Column
4. Modified Dean-Stark apparatus connected to Condensor equipped with water inlet and outlet
5. Rubber tubing (not shown)
6. Stand
7. Clamp holder
8. Clamp universal
9. Water bucket (not shown)
10. Aquarium pump (not shown)
11. Thermometers
12. 600 mL glass beaker (not shown)

The supporting equipment consists of:

a. 10 mL volumetric (graduated) cylinder
b. Plastic funnel
c. Sample tube
d. Cutting board
e. Gloves
f. Magnifying glass
g. Goggles
h. Rubber Stopper

Materials:

a. Nutmeg fruit
b. Nutmeg seed powder
c. Water
d. Boiling stone

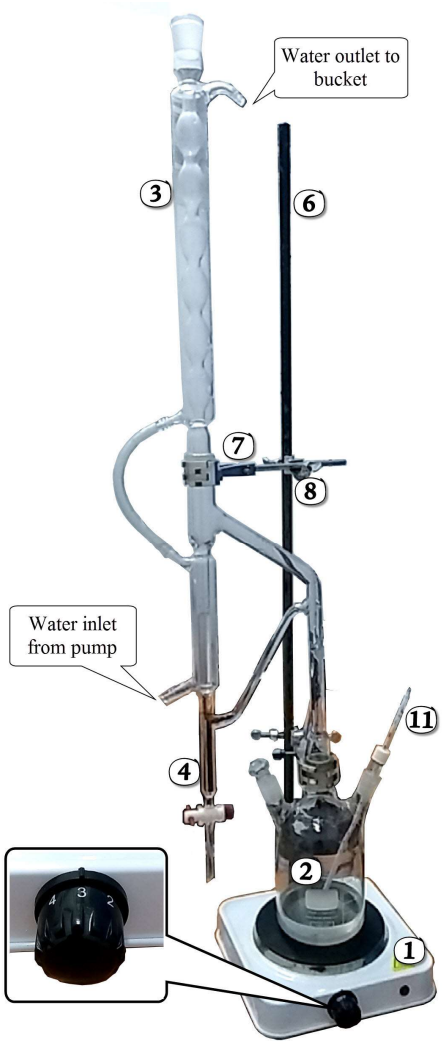

Figure 1. Hydrodistillation Apparatus, will be used to isolate nutmeg oil from nutmeg seeds

Experimental Procedure

1. Make sure that the experimental equipment has been installed properly.
2. Fill the flask with 400 mL of water. Put the thermometer into the flask. Ensure that the tip of thermometer does not touch the bottom of the flask.
3. Turn on the electric stove (adjust the power of the electric stove to setting number 3) and at the same time push the stopwatch START button. ***BE CAREFUL. DO NOT TOUCH THE ELECTRIC STOVE PLATE.*** **The stove is equipped with automatic ON-OFF to maintain the temperature and to prevent overheating.**
4. Record the temperature of the water every 0.5 minute up to 12 minutes. Write the data on the answer sheet. After an interval of 12 minutes turn off the stove, and turn off the stopwatch.
5. Take the thermometer out and replace with cap provided.
6. With the water still in the flask, add more water up to 500 mL. Pour nutmeg powder that has been provided (120 grams) to the flask by using a funnel that has been provided. Add 3-5 pieces of boiling stone provided to the flask as well.
7. Turn on the electric stove, adjust the power to maximum setting (setting number 5). Continue heating until 90 minutes. Use stopwatch provided.
8. While waiting the 90 minutes, answer the **PART ONE: Physics, The effectiveness of energy absorption by water** questions on the answer sheet.
9. After you finish working on the problems of PART ONE, continue to work on **Biology experiments** as follows.
10. On the table you have been provided with a nutmeg fruit (including seed), the longitudinal and cross sections of nutmeg fruits and seeds.
11. Examine the nutmeg fruit and its parts carefully.
12. Examine the longitudinal and cross sections of fruit and seed and their parts.
13. Answer **PART TWO**: **Biology, Characteristics of Nutmeg** questions on the answer sheets provided.
14. After 90 minutes heating of the flask, turn off the electric stove. Measure the volume of nutmeg oil that has been produced in the Dean-stark. You may have to wait a while until the nutmeg oil is separated from water.

15. Transfer the entire collected nutmeg oil in the sample tube provided, close it, label it and leave it together with your answer sheets. Write your team code on the label provided and stick it to the sample tube.
16. Answer **PART THREE: Chemistry, Nutmeg Oil Distillation** questions on the answer sheets provided.

QUESTIONS

PART ONE: Physics, The effectiveness of energy absorption by water [13 point]

Transitions between solid, liquid, and gaseous phases typically involve large amounts of heat absorbed. If heat were added at a constant rate to a mass of ice to take it through its phase changes to liquid water and then to steam, the energies required to accomplish the phase changes (called the latent heat of fusion and latent heat of vaporization) would lead to plateaus in the temperature vs time graph. The graph below (Figure 1) presumes that the pressure is one standard atmosphere.

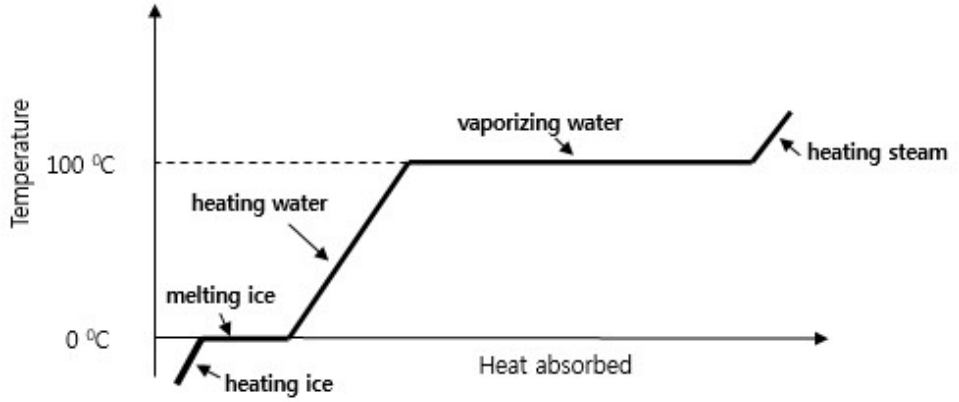

Figure 1. Graph of temperature versus heat absorbed

Ph-1 [3.0 points] Make a graph of the temperature (°C) of water as a function of time (in minute).

Ph-2 [1.5 points] Determine the linear range of water temperature change (ΔT) and time change (Δt).

Ph-3 [2.0 points] Calculate the rate of change of temperature of water (in °C/s) with respect to time by using the linear part of the graph (which means linear process in water).

Ph-4 [2.0 points] Calculate how much electrical energy (in Joule) is used within the linear part of the graph (electric power used by the stove is 600W).

Ph-5 [1.5 points] Calculate how much heat (in Joules) is used to increase the temperature of the water in the linear part of the graph. (Note that c_{water} = 4180 J/kg.°C and ρ = 1000 kg/m^3).

Ph-6 [1.5 points] Calculate how much heat (in Joule) is released into the environment within the linear part of the graph.

Ph-7 [1.5 points] Calculate the percentage of energy used to raise the temperature of water with respect to the total energy of the stove within the linear part of the graph.

PART TWO: Biology, Characteristics of Nutmeg [13 points]

A. Nutmeg Fruit

Bi-1 [2.0 points] Draw the longitudinal section of the fruit with the seed intact.

Bi-2 [3.0 points] Label parts of the fruit with reference provided on the answers box.

Show the fruit parts by arrows. Choose the corresponding parts from the answers box and write down the answer by writing the letter only (for example A, B, C etc.).

B. Nutmeg Seed

Bi-3 [3.0 points] Draw the cross section of the seed.

Bi-4 [2.0 points] Label parts of the seed with reference provided on the answers box.

Show the seed parts by arrows. Choose the corresponding parts from the answers box and write down the answer by writing the letter only (for example A, B, C etc).

Answers Box

A. Receptacle	E. Locule	I. Seed	M. Embryo
B. Mesocarp	F. Nucellus	J.Testa/Seed Coat	N. Exocarp
C. Peduncle	G. Endosperm	K. Arillus	O. Placenta
D. Perisperm	H. Endocarp	L. Funiculus	P. Hypanthium

C. Nutmeg Fruit and Seed Characteristics

Fruit and Seed Classification:

Simple fruit	:	A fruit that develops from a single pistil
Compound fruit	:	A fruit in which one flower contains several separate ovaries which merge during development (aggregate) or a fruit in which several flowers, each with an ovary, develop into small fruits that are clustered or fused together into a larger fruit (multiple)
True fruit		A fruit in which all tissues are derived from a ripened ovary and its contents
Accessory fruit	:	A fruit that develops from a ripened ovary or

		ovaries but includes a significant portion derived from non-ovarian tissue
Fleshy fruit	:	A fruit that has a soft and pulpy wall at maturity
Dry fruit	:	A fruit that has a dry wall at maturity
Pome	:	A fruit that derived from several carpels, receptacle and outer portion
Drupe	:	A fruit that derived from a single carpel and containing (usually) one seed
Monocotyledon	:	Having a single cotyledon in the seed
Dicotyledon	:	Having two cotyledons in the seed
Round	:	Having the shape of a sphere or ball
Ovoid	:	Egg-shaped with the broader end at the base

Bi-5 [3.0 points] Examine the fruit and the seed carefully. Tick (√) one correct answer on each classification categories (A-F) in the box provided below.

Question:	**Answer:**	
A. Fruit origin:	☐ Simple fruit	☐ Compound fruit
B. Fruit composition:	☐ True fruit	☐ Accessory fruit
C. Fruit description:	☐ Fleshy fruit	☐ Dry fruit
D. Fruit type:	☐ Pome	☐ Drupe
E. Seed cotyledon:	☐ Monocotyledon	☐ Dicotyledon
F. Seed shape:	☐ Round	☐ Ovoid

PART THREE: Chemistry, Nutmeg Oil Distillation [14.0 points]

After conducting experiment by using 120 g of ground nutmeg seed, you have obtained certain amount of nutmeg oil.

Ch-1 [4.50 points] How much is the volume of nutmeg oil you have obtained?

Ch-2 [1.50 point] It is known that the mass of exactly 1.00 mL of nutmeg oil is 0.862 g at 25 ^{o}C. What is the percentage by mass of nutmeg oil in nutmeg seed according to your experiment if it is measured at 25 ^{o}C?

Ch-3 [3.00 point] It is known that the main component of nutmeg oil is myristicin. Assume that your sample of nutmeg oil contains 65% of myristicin ($C_{11}H_{12}O_3$) by mass.

(a) [1.5 point] Calculate the number of myristicin molecules in your sample.

(b) [1.5 point] Calculate the mass of the carbon in grams in the myristicin in your sample. (atomic mass of C = 12, H = 1, and O = 16)

Ch-4 [1.00 point] Based on the result of your experiment, calculate how many kilograms of nutmeg seed powder are required to produce 100 grams of nutmeg oil?

Ch-5 [0.50 point] What is the function of boiling stones added in your experiment?
(a) to accelerate the heating of water
(b) to speed up the separation of nutmeg oil from water
(c) to assist the distribution of heat inside the cylindrical flask content.

Ch-6 [0.50 point] What is the main aim of using nutmeg seed powder rather than nutmeg seed granules in your experiment?
(a) to increase the solubility of nutmeg seed in water
(b) to increase the contact surface of nutmeg seed and water
(c) to speed up the evaporation of water in the flask.

Ch-7 [0.75 point] The separation of water and nutmeg oil in the Dean-Stark apparatus reflects the principle of .....
(a) like dissolves like
(b) vapor pressure difference
(c) chemical equilibrium.

Ch-8 [0.75 point] If the flow of cooling water in your experiment is changed from upper to lower part of the condensor, the condensation of the steam and nutmeg oil will be .....
(a) more effective
(b) less effective
(c) no effect.

Ch-9 [0.75 point] Which of these following alternative separation techniques can be used to obtain nutmeg oil from the seed of nutmeg
(a) Centrifugation
(b) Solvent extraction
(c) Paper chromatography

Ch-10 [0.75 point] What kind of changes in the experimental design would not reduce the yield of nutmeg oil
(a) Heating too rapidly
(b) Using more boiling stones
(c) Using too short water condensor

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EXPERIMENT COMPETITION

DECEMBER, 8th 2016

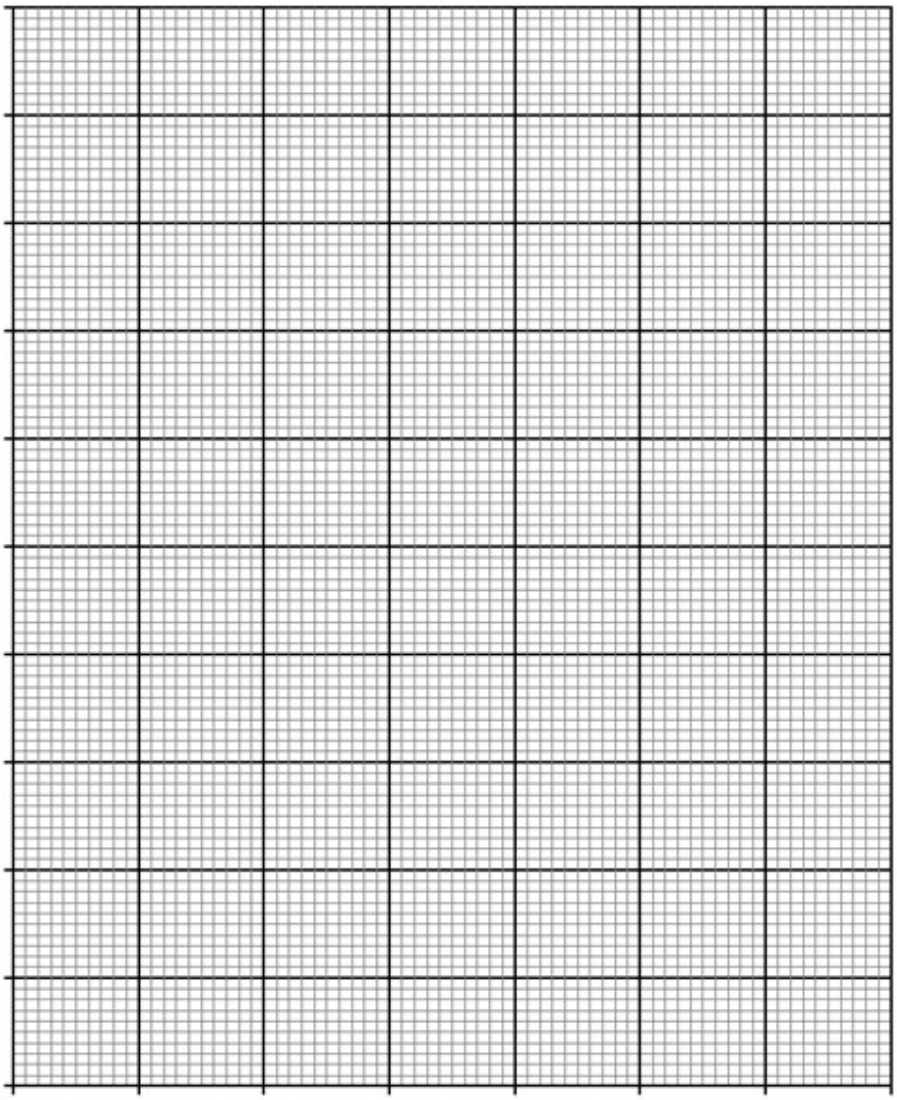
ANSWER SHEET

Country			
	Student 1	Student 2	Student 3
Name			
Team Code			
Signature			

PART ONE: Physics, The effectiveness of energy absorption by water [13.0 points]

Data

	t(min)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	T (°C)									
	t(min)	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
	T (°C)									
	t(min)	9.0	9.5	10.0	10.5	11.0	11.5	12.0		
	T (°C)									

Question (Points)	Make a graph of the temperature (°C) of water as a function of time (in minute).
Ph-1 (3.0)	

Question (Points)	Determine the linear range of watertemperature change (ΔT) and time change (Δt).
Ph-2 (1.5)	
Question (Points)	Calculate the rate of water temperature change (in °C/s) with respect to time by using the linear part of the graph(which means linear process in water).
Ph-3 (2.0)	

Question (Points)	Calculate how much electrical energy (in joule) is used within the linear part of the graph (electric power used by the stove is 600W).
Ph-4) (2.0)	
Question (Points)	Calculate how much heat (in joules) is used to increase the temperature of the water in thelinear part of the graph. (Note that c_{water} = 4180 J/kg.°C and ρ = 1000 kg/m^3).
Ph-5 (1.5)	

Question (Points)	Calculate how much heat (in joule) is released into the environment within the linear part of the graph.
Ph-6 (1.5)	
Question (Points)	Calculate the percentage of energy used to raise the temperature of water with respect to the total energy of the stove within the linear part of the graph.
Ph-7 (1.5)	

---------- DO NOT WRITE BELOW ----------

Total points for PART ONE	

	Country		
	Student 1	Student 2	Student 3
Name			
Team Code			
Signature			

PART TWO: Biology, Characteristics of Nutmeg [13.0 points]

A. Nutmeg Fruit

Question (Points)	Bi-1. Draw the longitudinal section of the fruit with the seed intact. Bi-2. Label parts of the fruit with reference provided on the answers box. Show the fruit parts by arrows. Choose the corresponding parts from the answers box and write down the answer by writing the letter only (for example A, B, C etc.).
Bi-1 (2.0) Bi-2 (3.0)	

B. Nutmeg Seed

Question (Points)	Bi-3. Draw the cross section of the seed. Bi-4. Label parts of the seed with reference provided on the answers box. Show the seed parts by arrows. Choose the corresponding parts from the answers box and write down the answer by writing the letter only (for example A, B, C etc.)
Bi-3 (3.0) Bi-4 (2.0)	

C. Nutmeg Fruit and Seed Characteristics

Question (Points)	Tick (√) one correct answer on each classification categories (A-F) in the box provided below.			
Bi-5 (3.0)	A. Fruit origin:	☐	Simple fruit	☐ Compound fruit
	B. Fruit composition:	☐	True fruit	☐ Accessory fruit
	C. Fruit description:	☐	Fleshy fruit	☐ Dry fruit
	D. Fruit type:	☐	Pome	☐ Drupe
	E. Seed cotyledon:	☐	Monocotyledon	☐ Dicotyledon
	F. Seed shape:	☐	Round	☐ Ovoid

---------- DO NOT WRITE BELOW ----------

Total points for PART TWO	

	Country		
	Student 1	Student 2	Student 3
Name			
Team Code			
Signature			

PART THREE: Chemistry, Nutmeg Oil Distillation [14.0 points]

After conducting experiment by using 120 g of ground nutmeg seed, you have obtained certain amount of nutmeg oil.

Question (Points)	How much is the volume of nutmeg oil you have obtained?
Ch-1 (4.50)	

Question (Points)	It is known that the mass of exactly 1.00 mL of nutmeg oil is 0.862 g at 25 ^{o}C. What is the percentage by mass of nutmeg oil in nutmeg seed according to your experiment if it is measured at 25 ^{o}C?
Ch-2 (1.50)	

Question (Points)	It is known that the main component of nutmeg oil is myristicin. Assume that your sample of nutmeg oil contains 65% of myristicin ($C_{11}H_{12}O_3$) by mass. **(a) [1.5 point]** Calculate the number of myristicin molecules in your sample. **(b) [1.5 point]** Calculate the mass of the carbon in grams in the myristicin in your sample. (atomic mass of C = 12, H = 1, and O = 16)
Ch-3 (3.00)	

Question (Points)	Based on the result of your experiment, calculate how many kilograms of nutmeg seed powder are required to produce 100 grams of nutmeg oil?
Ch-4 (1.00)	

Question (Points)	What is the function of boiling stones added in your experiment? (a) to accelerate the heating of water (b) to speed up the separation of nutmeg oil from water (c) to assist the distribution of heat inside the cylindrical flask content.
Ch-5 (0.50)	Choose one correct answer by putting an X in one of the boxes below. ☐ (a) ☐ (b) ☐ (c)

Question (Points)	What is the main aim of using nutmeg seed powder rather than nutmeg seed granules in your experiment? (a) to increase the solubility of nutmeg seed in water (b) to increase the contact surface of nutmeg seed and water (c) to speed up the evaporation of water in the flask.
Ch-6 (0.50)	Choose one correct answer by putting an X in one of the boxes below. ☐ (a) ☐ (b) ☐ (c)

Question (Points)	The separation of water and nutmeg oil in the Dean-Stark apparatus reflects the principle of ..... (a) like dissolves like (b) vapor pressure difference (c) chemical equilibrium.
Ch-7 (0.75)	Choose one correct answer by putting an X in one of the boxes below. ☐ (a) ☐ (b) ☐ (c)

Question (Points)	If the flow of cooling water in your experiment is changed from upper to lower part of the condensor, the condensation of the steam and nutmeg oil will be ..... (a) more effective (b) less effective (c) no effect.
Ch-8 (0.75)	Choose one correct answer by putting an X in one of the boxes below. ☐ (a) ☐ (b) ☐ (c)

Question (Points)	Which of these following alternative separation techniques can be used to obtain nutmeg oil from the seed of nutmeg (a) Centrifugation (b) Solvent extraction (c) Paper chromatography
Ch-9 (0.75)	Choose one correct answer by putting an X in one of the boxes below. ☐ (a) ☐ (b) ☐ (c)

Question (Points)	What kind of changes in the experimental design would not reduce the yield of nutmeg oil (a) Heating too rapidly (b) Using more boiling stones (c) Using too short water condensor
Ch-10 (0.75)	Choose one correct answer by putting an X in one of the boxes below. ☐ (a) ☐ (b) ☐ (c)

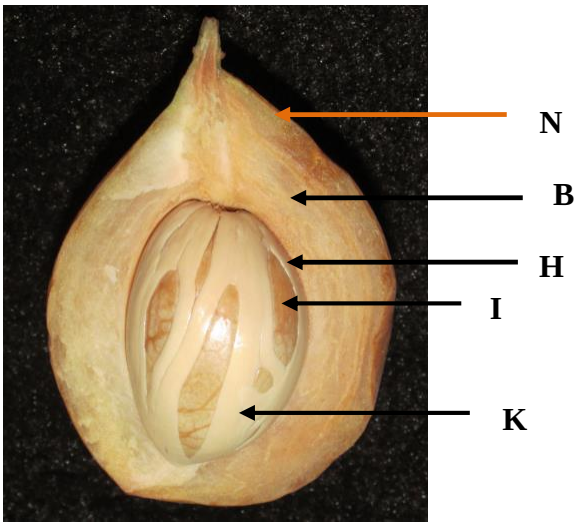
---------- DO NOT WRITE BELOW ----------

Total points for PART THREE	

PART ONE	
PART TWO	
PART THREE	
Total Points of Experiment Competition	

PART TWO: Biology, Characteristics of Nutmeg [13.0 points]

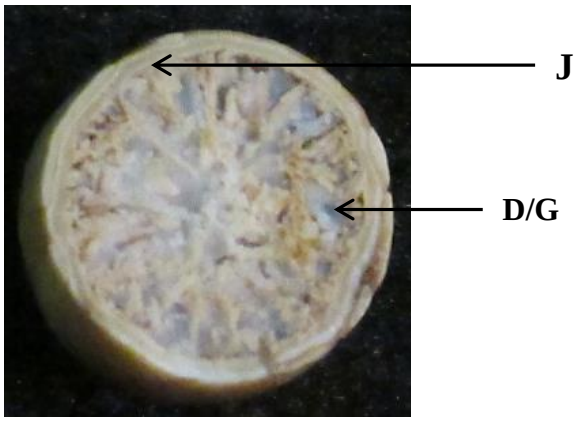
A. Nutmeg Fruit

Question	**Bi-1.** Draw the longitudinal section of the fruit with the seed intact! **Bi-2.** Label parts of the fruit with reference provided on the answers box. Show the fruit parts by arrows. Choose the corresponding parts from the answers box and write down the answer by writing the letter only (for example A, B, C etc.).	Points	Max
			
Bi-1	Drawing the correct longitudinal section of the fruit	0.25	2.0
	Drawing the cross section of the fruit	0.0	
	Size of the drawing is appropriate to the original fruit = 0.5 and correct proportion of the different parts = 0.5	1.0	
	Drawing the correct and complete 3 parts of the fruit (fruit, seed and arillus @ 0.25).	0.75	
	No drawing	0.0	
Bi-2	Correct labelling B = 0.6 point H = 0.6 point N = 0.6 point I = 0.6 point K = 0.6 point	3.0	3.0

Notes:

Pericarp	:	the walls of a ripen ovary or fruits (fruit coat: exocarp/epicarp, mesocarp and endocarp)
Seed	:	the fertilized mature ovule of flowering plant containing an embryo, the germ of propagative source, offspring or progeny)
Arillus/Aril/Mace	:	specialized outgrowth of a seed that partly or completely covered the seed

B. Nutmeg Seed

Question	**Bi-3. Draw the cross section of the seed!** **Bi-4.** Label parts of the seed with reference provided on the answers box. Show the seed parts by arrows. Choose the corresponding parts from the answers box and write down the answer by writing the letter only (for example A, B, C etc)	Points	Max
			
Bi-3	Drawing the correct cross section of the seed	0.5	3.0
	Drawing the longitudinal section of the seed	0.0	
	Size of the drawing is appropriate to the original seed	0.5	
	Correct drawing of the internal seed parts (testa/seed coat (J)= 1.0 point, endospem/perisperm (D/G))= 1.0 point Drawing the incomplete internal parts of the seed (without testa (J) or endosperm/perisperm (D/G) = 1.0 point	2.0	
	No drawing	0.0	
Bi-4	Correct labelling : testa/seed coat (J)= 1.0 point, endosperm/perisperm (D/G) = 1.0 point. Only one correct labeling: testa/seed coat (J) or endosperm/perisperm (D/G) = 1.0 point	2.0	2.0
	No label	0.0	

Notes:

Seed coat/Testa : the outer protective covering of a seed
Endosperm : a tissue produced inside the seeds of most flowering plants it surrounds the embryo and provide nutrition in the form of starch, it can also contain oils and protein

C. Nutmeg Fruit and Seed Characteristics

Question (Points)	Fruit and Seed Classification Tick (√) one correct answer on each classification categories (A-F) in the box provided below! (0.5 point for each correct answer)				
Bi-5 (3.0)	A. Fruit origin:	√	Simple fruit		Compound fruit
	B. Fruit composition:	√	True fruit		Accessory fruit
	C. Fruit description:	√	Fleshy fruit		Dry fruit
	D. Fruit type:		Pome	√	Drupe
	E. Seed cotyledon:		Monocotyledon	√	Dicotyledon
	F. Seed shape:		Round	√	Ovoid

PART THREE: Chemistry, Nutmeg Oil Distillation [14.0 points]

After conducting experiment by using 120 g of ground nutmeg seed, you have obtained certain amount of nutmeg oil.			
Question	How much is the volume of nutmeg oil you have obtained?	**Points**	**Max**
Ch-1	Sample collected by students is free of water	2.00	4.50
	Volume of Nutmeg Oil (mL):		
	> 4.00	2.50	
	2.50 – 3.99	2.00	
	1.00 – 2.49	1.50	
	0.00 – 0.99	0.50	
	If wrong fraction (only water) is collected	0.00	
Question	It is known that the mass of exactly 1.00 mL of nutmeg oil is 0.862 g at 25 ^{o}C. What is the percentage by mass of nutmeg oil in nutmeg seed according to your experiment if it is measured at 25 ^{o}C?	**Points**	**Max**
Ch-2	Mass of nutmeg oil = volume (mL) x density (g/mL) =..... mL x 0.862 (g/mL) = ... g	0.75	1.50
	Percentage of nutmeg oil in nutmeg seed: = {mass of nutmeg oil (~~g~~)/mass of nutmeg seed (~~g~~)} x 100 % = ... %	0.75	
Question	It is known that the main component of nutmeg oil is myristicin. Assume that your sample of nutmeg oil contains 65% of myristicin ($C_{11}H_{12}O_3$) by mass. **(a) [1.5 point]** Calculate the number of myristicin molecules in your sample. **(b) [1.5 point]** Calculate the mass of the carbon in grams in the myristicin in your sample. (atomic mass of C = 12, H = 1, and O = 16)	**Points**	**Max**
Ch-3	Molecular mass of myristicin = (12 x 11) + (1 x 12) + (16 x 3) = 192	0.50	3.00
	Mass of myristicin in nutmeg oil: = volume of nutmeg oil (~~mL~~) x density (g/~~mL~~) x 0.65 **= ..... x 0.862 x 0.65 g**	0.50	
	Number of moles of myristicin: = (gram of myristicin)/192 = ... moles	0.50	
	Number of molecules of myristicin: = number of mole of myristicin × Avogadro number = number of mole of myristicin × 6.02x10^{23} molecule = ... ×10^{23} molecules	0.50	

	Mass of carbon in the myristicin of your nutmeg oil: = 132/192 x gram of myristicin = ... grams	1.00	
Question	Based on the result of your experiment, calculate how many kilograms of nutmeg seed powder are required to produce 100 grams of nutmeg oil?	**Points**	**Max**
Ch-4	Assume that the percentage of nutmeg oil in nutmeg seed obtained from question Ch-3 = a % The mass of nutmeg seed powder required to produce 100 grams (0.1 kg) of nutmeg oil: = (0.1 x 100)/a kg = ...kg	1.00	1.00
Question	What is the function of boiling stones added in your experiment? (a) to accelerate the heating of water (b) to speed up the separation of nutmeg oil from water (c) to assist the distribution of heat inside the cylindrical flask content.	**Points**	**Max**
Ch-5	Answer: (c) to assist the distribution of heat inside the cylindrical flask content.	0.50	0.50
Question	What is the main aim of using nutmeg seed powder rather than nutmeg seed granules in your experiment? (a) to increase the solubility of nutmeg seed in water (b) to increase the contact surface of nutmeg seed and water (c) to speed up the evaporation of water in the flask.	**Points**	**Max**
Ch-6	Answer: (b) to increase the contact surface of nutmeg seed and water	0.50	0.50
Question	The separation of water and nutmeg oil in the Dean-Stark apparatus reflects the principle of ..... (a) like dissolves like (b) vapor pressure difference (c) chemical equilibrium.	**Points**	**Max**
Ch-7	Answer: (a) like dissolves like	0.75	0.75
Question	If the flow of cooling water in your experiment is changed from upper to lower part of the condensor, the condensation of the steam and nutmeg oil will be ..... (a) more effective (b) less effective (c) no effect.	**Points**	**Max**
Ch-8	Answer (b) less effective	0.75	0.75

Question	Which of these following alternative separation techniques can be used to obtain nutmeg oil from the seed of nutmeg (a) Centrifugation (b) Solvent extraction (c) Paper chromatography	**Points**	**Max**
Ch-9	Answer: (b) Solvent extraction	0.75	0.75
Question	What kind of changes in the experimental design would not reduce the yield of nutmeg oil (a) Heating too rapidly (b) Using more boiling stones (c) Using too short water condensor	**Points**	**Max**
Ch-10	Answer: (b) Using more boiling stones	0.75	0.75

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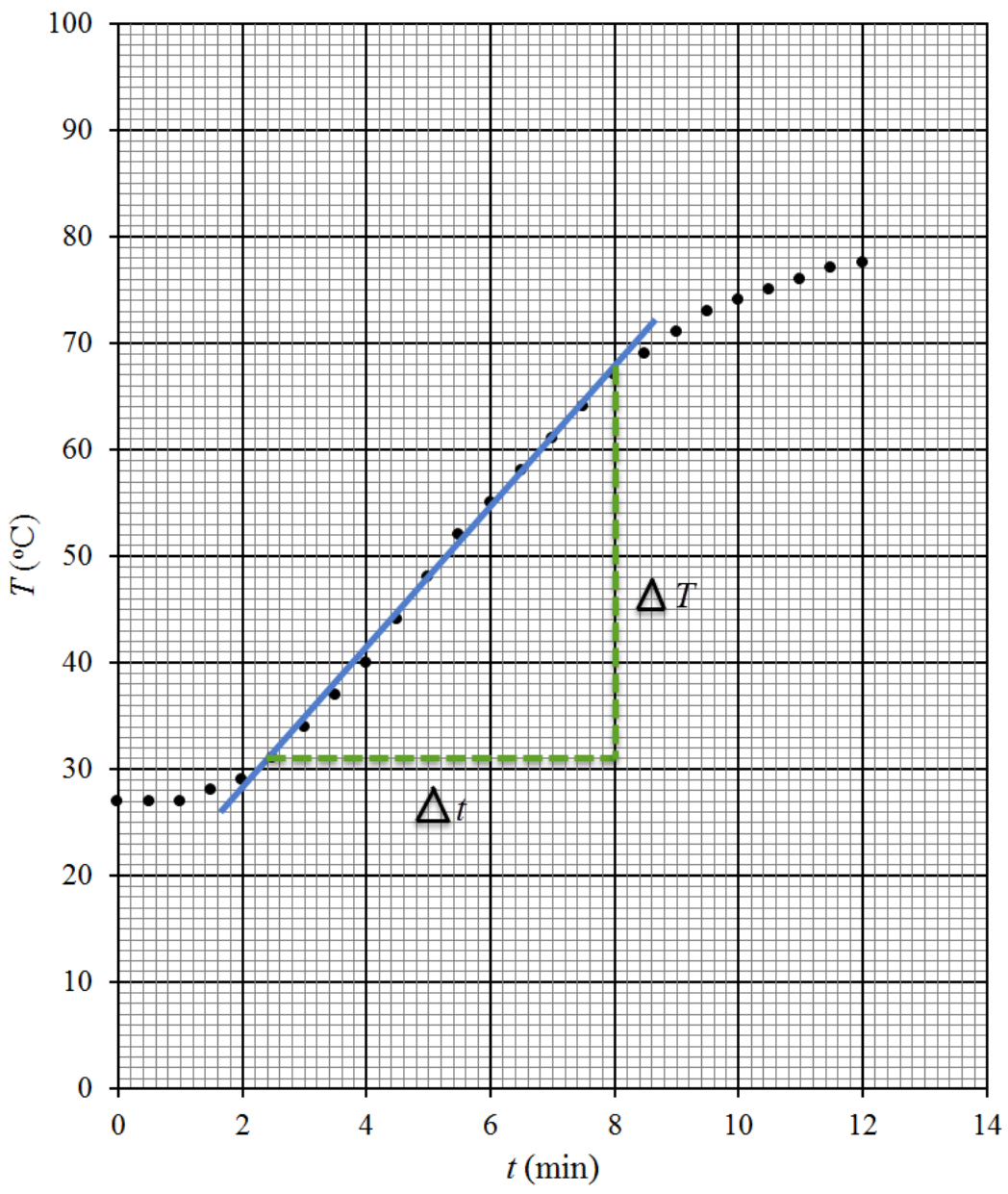
PART ONE: Physics, The effectiveness of energy absorption by water [13.0 points]										
Experimental Data										
	t(min)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	T (°C)	27	27	27	28	29	31	34	37	40
	t(min)	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
	T (°C)	44	48	52	55	58	61	64	67	69
	t(min)	9.0	9.5	10.0	10.5	11.0	11.5	12.0		
	T (°C)	71	73	74	75	76	77	77.5		

Question (Points)	Graph
Ph-1 (3.0)	

Question	Make a graph of the temperature of water as a function of time!	**Points**	**Max**
Ph-1			
	Name of both axis	0.5	3.0
	Unit of axis	0.5	
	Accuracy point positions of data (correctness of the data plotting)	2.0	
Question	Determine the linear range of water temperature change (ΔT) and time change (Δt)!	**Points**	**Max**
Ph-2 (1.5)	ΔT in the linear part	0.75	1.5
	Δt in the linear part	0.75	
	No answer or any other value	0.0	0.0
Question	Calculate the rate of water temperature change (in °C /s) with respect to time by using the linear part of the graph(which means linear process in water)!	**Points**	**Max**
Ph-3 (2.0)	Slope = (depending on the linear part of the graph)		2
	No answer or any other value		0.0
Question	Calculate how much electrical energy (in joule) is used within the linear part of the graph (electric power used by the stove is 600W)!	**Points**	**Max**
Ph-4 (2.0)	Electric energy = $E_E = P \times \Delta t$		
	E_E = (600W) x (Δt [in minute])x (60s), (Δt depends on student's linear part of graph) Correct formula = 1.0 point	1	2.0
	Correct calculation (in joule) = 1.0 point (units may not be stated)	1	
	E_E = (600W)x (Δt[in minute]), (Δt depends on student's linear part of graph) Correct calculation	0.5	1.0
	Correct formula	0.5	
	(units may not be stated)		

Question	Calculate how much heat (in joule) is received by water within the linear part of the graph! (Note that $c_{water} = 4180\,\text{J/kg.°C}$).	Points	Max
Ph-5 (1.5)	$\rho_{\text{water}} = 1\,\text{g/cm}^3$ $c_{\text{water}} = 4180\,\text{J/kg.°C}$ $V_{\text{water}} = 400\ \text{mL}$ $m_{\text{water}} = \rho_{\text{water}} \times V_{\text{water}} = (1)\times(400) = 400\text{g} = 0.4\text{kg}$ $Q_{water} = m_{water} \times c_{water} \times \Delta T$		
	Correct formula	0.5	1.5
	Correct calculation (in joule)	1.0	
	Correct calculation (units may not be stated)	0.5	1.0
	Correct formula	0.5	
	No answer or any other value	0.0	0.0
Question	Calculate how much heat (injoule) is released into the environment during thelinear partof the graph!	**Points**	**Max**
Ph-6 (1.5)	$\Delta Q = E_E - Q_{water}$		
	Correct formula	0.75	1.5
	Correct calculation (in joule)	0.75	
	Correct calculation (units may not be stated)	0.5	1.0
	Correct formula	0.5	
	No answer or any other value	0.0	0.0

Question	Calculate the percentage of energy absorbed by water with respect to the total energy of the stovewithin the linear part of the graph!	Points	Max
Ph-7 (1.5)	$\eta = (mc\Delta T) \div (P\Delta t) \times 100\%$		
	Correct formula	0.5	1.5
	Correct calculation (in joule)	1.0	
	Correct calculation (units may not be stated)	0.5	1
	Correct formula	0.5	
	No answer or any other value	0.0	0.0