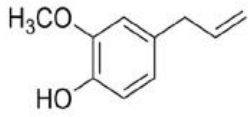
I. Essential Oil of Clove and Virgin Coconut Oil (VCO)

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.

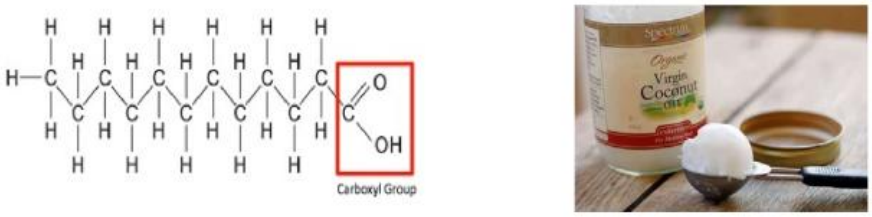


Fig. I.2 Chemical structure of lauric acid as the most abundant constituent of fatty acid in VCO

[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 $p_{\text{atm}} = 1.00$ 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.

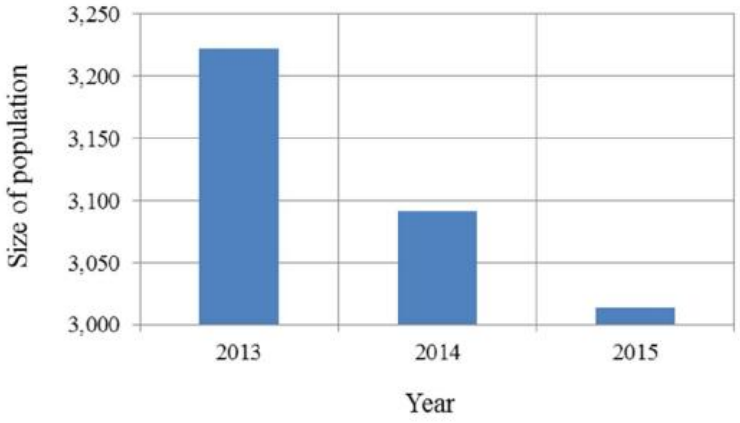


Figure of the Komodo dragon population from 2013 to 2015

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.

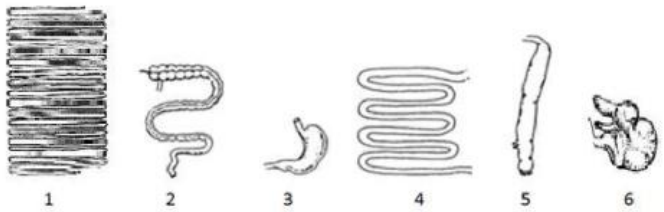


Figure of different parts of the alimentary canals of vertebrate animals

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.

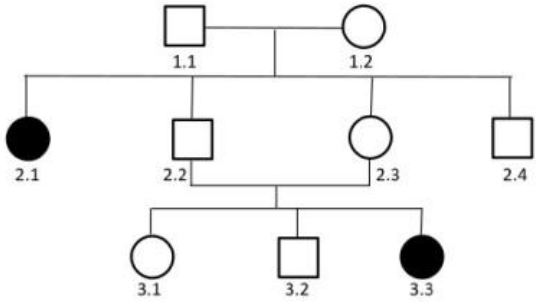


Figure of pedigree of Komodo dragons

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

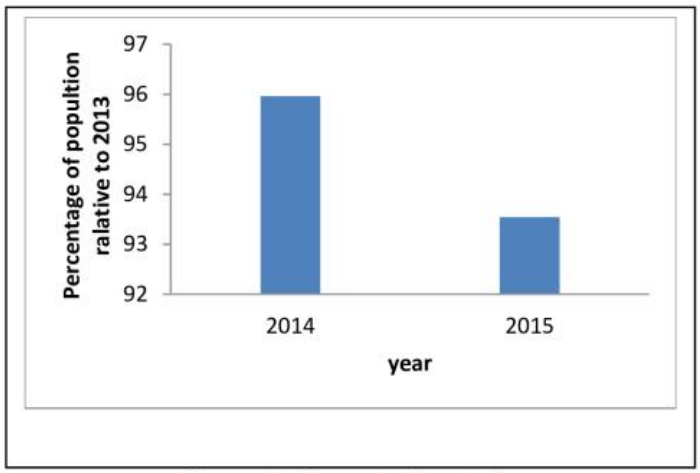
A.	An animal temperature does not fluctuate with the environment
B.	Predator
C.	First level consumer
D.	Animals that use only behavioral adaptation to manipulate their temperature
E.	Viviparous
F.	Animals that are hot when their environment is hot and cold when their environment is cold
G.	Third trophic 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

FINAL ANSWER FOR BIOLOGY SOLUTION : 6 Desember 2016

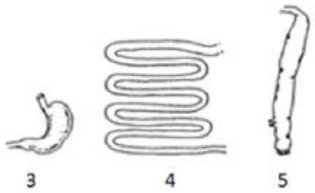
1.	Answer : D and F
Point: 1	Explanation : D. Animals that use behavioral adaptation to manipulate temperature F. Ectothermic animal: Animals referred to cold blooded, they are hot when their environment is hot and cold when their environment is cold

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^NZ^n 1.2 : Z^NW 2.1 : Z^nW 2.2 : Z^NZ^n 2.3 : Z^NW 3.1 : Z^NW 3.3 : Z^nW

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

13th INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

IJSO

BALI, INDONESIA 2016

Science for Creative Innovation

THEORY COMPETITION

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

13th INTERNATIONAL JUNIOR SCIENCE OLYMPIAD

IJSO

BALI, INDONESIA 2016

Science for Creative Innovation

THEORY COMPETITION

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 $\leq V \leq$ 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 $\leq V <$ 1.45 L or 1.55 L $< V \leq$ 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 $b = 5.55 \times 10^{-2}$ kg/s The value b $5.45 \leq b \leq 5.65 \times 10^{-3}$ 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 $5.35 \leq b < 5.45 \times 10^{-2}$ kg/s or $5.65 < b \leq 5.75 \times 10^{-2}$ 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° $\leq \theta \leq$ 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° $\leq \theta <$ 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.