

THEORY EXAMINATION RULES

1. You are NOT allowed to bring any personal items into the examination room, except for the water bottle, personal medicine or approved personal medical equipment.
2. You must sit at your designated desk and must always ensure that the camera/supervisor is able to clearly see you.
3. Check the stationery items (pen, calculator, and scrap paper/rough work sheet) provided by the organizers.
4. Do NOT start answering the questions before the “START” signal.
5. You are NOT allowed to leave the examination room during the examination except in an emergency in which case you will be accompanied by a supervisor.
6. If you need to visit the bathroom, please raise your hand.
7. Do NOT disturb other competitors. If you need any assistance, raise your hand and wait for a supervisor to come.
8. Do NOT discuss the examination questions. You must stay at your desk until the end of the examination time, even if you have finished the exam.
9. At the end of the examination time you will hear the “STOP” signal. Do NOT write anything more on the answer sheet after this stop signal.
10. Arrange the exam, answer sheets, and the stationary items (pen, calculator, and scrap paper) neatly on your desk. All the pages will be submitted back including the question paper and rough work.
11. Do not leave the room before all the answer sheets have been collected and Supervisors give you a signal to leave the room.

Theory



G0-2

TWN Fu (Chinese Taipei)

THEORY EXAMINATION INSTRUCTIONS

1. After the “START” whistle, you will have 3 hours to complete the exam.
2. Please confirm that the student code printed on your question paper and answer sheet is same as your student code provided to you by organizers.
3. You have 18 pages of answer sheets—including the front page. Raise your hand, if you find any sheets missing.
4. Read the problems carefully and write the correct answers in the corresponding boxes of the answer sheets. Before writing your answers on the answer sheets you may use the worksheet provided to avoid errors on your answer sheets. Only answers marked on the answer sheet will be evaluated, however additional worksheets will also be a part of the evaluation process wherever applicable.
5. The number of points that can be obtained is indicated for each question.
6. The total number of questions is 6. Check if you have a complete set of the test questions sheets(13pages, page 6–page 18)after the “START” signal is given. Raise your hand, if you find any sheets missing.
7. Useful information for answering the questions (atomic masses, constants, and formulas) is provided on page 4.
8. Always show your calculations. If you do not show your calculations, no points are awarded for the question.
9. You should write your final answers down in the appropriate number of significant digits.

Theory



G0-3

TWN Fu (Chinese Taipei)

List of Constants

- Avogadro' s constant $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
- Electronic charge $e = 1.602 \times 10^{-19} C$
- Molar gas constant $R = 8.314 \frac{J}{\text{mol } K}$
- Molar gas constant $R = 0.0821 \frac{L \text{ atm}}{\text{mol } K}$
- Molar gas constant $R = 1.982 \frac{\text{cal}}{\text{mol } K}$
- Planck' s constant $h = 6.626 \times 10^{-34} J s$
- Speed of light (in vacuum) $c = 2.998 \times 10^8 \frac{m}{s}$
- 1 atomic mass unit $1u = 931.5 \frac{MeV}{c^2}$
- Specific heat of water $= 4.2 \frac{kJ}{(kg)(K)}$
- 1 Dalton $= 1.661 \times 10^{-27} kg$
- $1 eV = 1.602 \times 10^{-19} J$
- $1 \text{ bar} = 10^5 Pa = 10^5 N m^{-2} = 1 \text{ atm}$
- $1 A^0 = 10^{-10} m$
- Acceleration due to gravity $g = 9.8 \frac{m}{s^2}$
- 1 Litre $= 10^3 cm^3 = 10^{-3} m^3$
- Density of water $= 1000 \frac{kg}{m^3}$
- Mechanical equivalent of heat $= 4.186 \frac{J}{cal}$
- 1 atmosphere $= 101325 P$

أولمبياد العلوم الدولي للناشئين الثامن عشر
18th International Junior Science Olympiad
Dubai, UAE الممثلة العربية للتجربة

TWN Fu (Chinese Taipei)

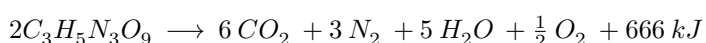
Group																		III	IV	V	VI	VII	VIII
I	II											1 H hydrogen 1							2 He helium 4				
3 Li lithium 7 4 Be beryllium 9		Key atomic number atomic symbol name relative atomic mass																5 B boron 11 6 C carbon 12 7 N nitrogen 14 8 O oxygen 16 9 F fluorine 19 10 Ne neon 20					
11 Na sodium 23 12 Mg magnesium 24												13 Al aluminium 27 14 Si silicon 28 15 P phosphorus 31 16 S sulfur 32 17 Cl chlorine 35.5 18 Ar argon 40	19 K potassium 39 20 Ca calcium 40	21 Sc scandium 45 22 Ti titanium 48 23 V vanadium 51 24 Cr chromium 52 25 Mn manganese 55 26 Fe iron 56 27 Co cobalt 59 28 Ni nickel 59 29 Cu copper 64 30 Zn zinc 65	31 Ga gallium 70 32 Ge germanium 73 33 As arsenic 75 34 Se selenium 79 35 Br bromine 80 36 Kr krypton 84								
37 Rb rubidium 85 38 Sr strontium 88	39 Y yttrium 89 40 Zr zirconium 91 41 Nb niobium 93 42 Mo molybdenum 96 43 Tc technetium — 44 Ru ruthenium 101 45 Rh rhodium 103 46 Pd palladium 106 47 Ag silver 108 48 Cd cadmium 112 49 In indium 115 50 Sn tin 119 51 Sb antimony 122 52 Te tellurium 128 53 I iodine 127 54 Xe xenon 131	55 Cs caesium 133 56 Ba barium 137	57–71 lanthanoids 72 Hf hafnium 178 73 Ta tantalum 181 74 W tungsten 184 75 Re rhenium 186 76 Os osmium 190 77 Ir iridium 192 78 Pt platinum 195 79 Au gold 197 80 Hg mercury 201 81 Tl thallium 204 82 Pb lead 207 83 Bi bismuth 209 84 Po polonium — 85 At astatine — 86 Rn radon —	87 Fr francium — 88 Ra radium —	89–103 actinoids 104 Rf rutherfordium — 105 Db dubnium — 106 Sg seaborgium — 107 Bh bohrium — 108 Hs hassium — 109 Mt meitnerium — 110 Ds darmstadtium — 111 Rg roentgenium — 112 Cn copernicium — 114 Fl flerovium — 116 Lv livermorium —																		
lanthanoids		57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium —	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175							
actinoids		89 Ac actinium —	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium —	94 Pu plutonium —	95 Am americium —	96 Cm curium —	97 Bk berkelium —	98 Cf californium —	99 Es einsteinium —	100 Fm fermium —	101 Md mendelevium —	102 No nobelium —	103 Lr lawrencium —							

Bullet and Cannon (5 points)

Please read the general instructions in the separate envelope before you start this problem.

Part A. The Modern day bullet (2.5 points)

Nitroglycerin is one of the important ingredients in modern day bullets. The nitration (self-combustion) of this material is written as



11.35 g of this material is used in a bullet cartridge of mass 100.0 g.

A.1	Find the molecular mass of nitroglycerine.	(0.5pt)
A.2	Find the number of moles of nitro-glycerine in one bullet cartridge.	(0.5pt)
A.3	Find the amount of energy released (numerical value with proper unit) during combustion of one bullet.	(0.5pt)
A.4	Assuming that the entire energy evolved during combustion is used to give kinetic energy to the bullet. Calculate the maximum possible muzzle velocity (numerical value with proper unit) of this bullet.	(1.0pt)

Theory

Part B. Traditional Cannon (2.5 points)

A traditional Cannon barrel of inner diameter 15.0 cm and length 5.0 m was filled with gunpowder (nitrocellulose) to 20% of its length and topped with a cannon ball of same diameter as the barrel.

When it is fired, all of the nitrocellulose burns instantly and produces gas with pressure of 1000 standard atmosphere. When the ball exits the barrel the gas temperature drops to $\frac{1}{3}$ rd of the temperature at the time of ignition. (Assume ideal gas situation)

B.1 Write the formula to find the pressure (final pressure P_2 in terms of initial pressure P_1 , initial volume V_1 , initial temperature T_1 , final volume V_2 and final temperature T_2) when the cannon ball exits the barrel. (0.5pt)

B.2 Calculate the pressure (numerical value with proper unit) on the ball when it exits the barrel. (1.5pt)
(Express your answers in three significant figures i.e. two digits after decimal)

B.3 Calculate the force (numerical value with proper unit) on the ball when it exits the barrel. (0.5pt)
(Express your answers in three significant figures i.e. two digits after decimal)

Theory

The Sand buggy and Abra (5 points)

Please read the general instructions in the separate envelope before you start this problem.

Part A. The sand buggy (3.0 points)

A sand buggy (shown in Figure 1) is a vehicle that is used for transportation in deserts. Consider a sand buggy of mass 200.0 kg travelling with a constant speed of 72.0 km/h climbing a sand dune which is shown as an inclined plane with an angle of inclination of 30° . The opposition to this motion offered by the sand is a fraction $f = 0.15$ of the normal force exerted on the buggy by the sand.



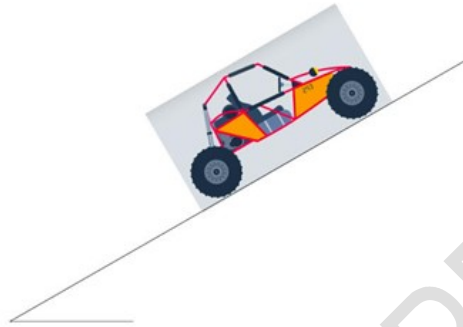
Figure 1 : Representative figure for sand buggy on a slope.

Theory

Q2-2

English (Official)

- A.1** Draw a VECTOR diagram showing all forces acting on the vehicle in the figure (1.0pt) below.



- A.2** Calculate the total force (numerical value with proper unit) that opposes the motion of the sand buggy up the incline. (0.5pt)

- A.3** Calculate the minimum power (numerical value with proper unit) of the engine of the sand buggy to sustain the upward motion. (0.5pt)

- A.4** If the engine suddenly stops during the course of its upward motion, calculate its retardation (numerical value with proper unit) . (0.5pt)

- A.5** How far will it travel (numerical value with proper unit) before coming to rest after the engine suddenly stops ? (0.5pt)

Part B. Abra boat ride (2.0 points)

Dubai city's traditional mode of transport to cross the creek is Abra boat ride (see Figure 2). Abra ride is one of the cheapest modes of transport which connects the Old Dubai to New Dubai.



Figure 2 : Representative figure for Abra boat floating in water.

The boats are about 6 m in length and seating arrangement is made of two parallel lines of benches on either side of the vertical plane dividing the boat lengthwise. The center of mass of the boat lies on the vertical line passing exactly through the center of the benches. Passengers can seat on either side on the benches facing the creek.

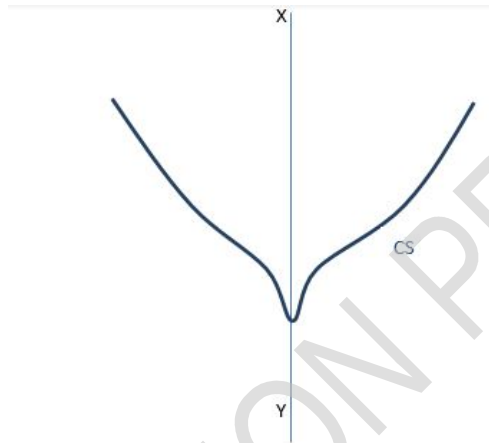
When the passengers are seated, their centers of mass can be considered to be at a height of 0.4 m above the deck. In case of a maximum payload the water level is 0.5 m below the deck, the buoyant force acts at a point 0.1 m below the water level and the center of mass of the boat lies 1.6 m below the deck. The mass of the unloaded boat is 1000 kg while the average mass of each passenger is 60 kg.

Theory

Q2-4

English (Official)

- B.1** Draw a schematic sketch along the line XY, of the positions of center of mass of the boat, center of buoyancy of the boat, center of mass of the passengers, and the deck level with respect to the water line and label the distances. CS – Represents the vertical cross section of the boat in the figure given below. (0.5pt)



- B.2** Calculate the maximum number of passengers such that the boat is prevented from capsizing. (1.5pt)

Theory

Please read the general instructions in the separate envelope before you start this problem and also write the correct units for all the quantities wherever necessary.

Dates are tropical fruits that grow on date palms. The origin of dates goes back to 5320 BC. Dates are a source of rich nutrients like carbohydrates, proteins, fibre, minerals, enzymes, and vitamins and thus form an essential staple food item for the people of UAE and other Middle East and North African countries. Dates are widely used in Emirati dishes. Dates have a high natural sugar content.

Sucrose (Molecular formula $C_{12}H_{22}O_{11}$), a disaccharide undergoes hydrolysis with excess of water in the presence of an acid catalyst to give a mixture of two isomeric monosaccharides, Glucose ($C_6H_{12}O_6$) and Fructose ($C_6H_{12}O_6$). Solutions of these optically active carbohydrates can rotate the plane of plane polarized light. Sucrose is dextrorotatory (clock wise rotation, +) whereas the mixture of Glucose and Fructose is laevorotatory (anticlockwise rotation, -).

The rate of hydrolysis of Sucrose is determined by measuring the angle of rotation of the plane of plane polarized light at regular time intervals during the course of the reaction. The angles of rotation are determined using a polarimeter.

A certain minimum amount of energy is required for the reaction in order to convert the reactants into products. This threshold energy for the reaction is called the Energy of Activation. It is determined by measuring the rate of a reaction at different temperatures.

A student added 20 cm^3 of 1 M HCl to 20 cm^3 of 20% Sucrose solution and transferred the mixture to a polarimeter tube of length 20 cm . He then recorded the angles of rotation at 303 K and 311 K as follows:

Temperature (K)	Time (s)	Angle of rotation ($^\circ$)
303	0	+12.5
303	600	-3.0
311	0	+12.5
311	600	-8.0

At the end of the hydrolysis, the angle of rotation was found to be -15.5° .

3.1 Help the student to determine the energy of activation of the hydrolysis in kJ/mol (2.0pt)

Theory

UAE has huge reserves of oil and natural gas with most of the oil reserves located in Abu Dhabi. The Zakum oil field is the third largest oil field in the Middle East. UAE has one of the largest petroleum refining industries in the world. Naturally occurring petroleum is a complex mixture of hydrocarbons with different molecular weights. In the petroleum industry complex organic molecules of high molecular weight are broken down into lower molecular weight compounds which are in greater demand. A catalyst is used for this process which is called Catalytic Cracking. The rate of cracking of petroleum depends largely on the temperature of the catalyst used. Micro porous aluminosilicate minerals called Zeolites are commonly used to catalyse the cracking of petroleum, which occurs in the tiny pores of the mineral.

A catalyst increases the rate of a reaction by lowering its energy of activation. A zeolite catalyst lowered the energy of activation of the cracking of petroleum from 66 kJ /mol to 60 kJ /mol at 27°C.

3.2	By what factor did the catalyst increase the reaction rate at 27°C?	(1.0pt)
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A green compound (A) is insoluble in water but dissolves with effervescence in dil HCl giving a green solution. When H_2S gas is passed through this solution, a black precipitate (B) is obtained. (B) dissolves in dil HNO_3 giving a blue solution of C. When $NaOH$ is added to this solution (C) a blue precipitate (D) is obtained that dissolves in ammonia solution to give a dark blue coloured solution.

3.3	Identify (A), (B), (C) and (D). Write correctly balanced chemical equations to show the above processes.	(2.0pt)
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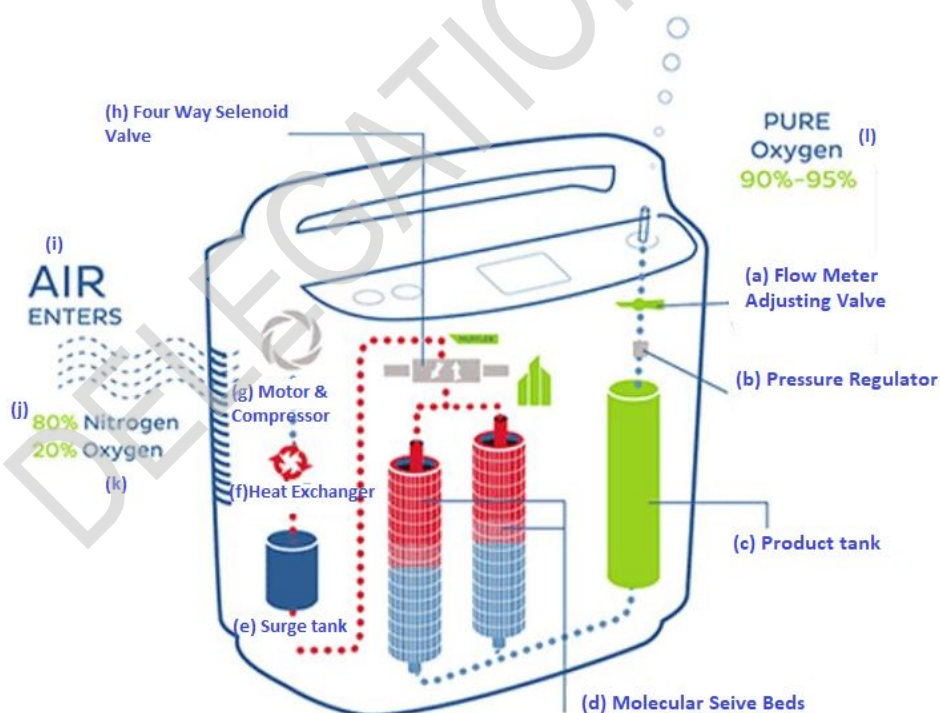
Please read the general instructions in the separate envelope before you start this problem and also write the correct units for all the quantities wherever necessary.

The novel COVID-19 pandemic has brought unique challenges in various aspects of life. Coronaviruses belong to the family of viruses that causes severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and other related disorders.

Covid-19 is an airborne disease which transmits through by suspending infectious aerosols in air for considerable time.

United Arab Emirates (UAE) has taken unparalleled precautionary measures including deep sanitisation, mandatory vaccinations and other safety measure to curb it's spread..

Oxygen saturation in blood or SpO_2 is a measure of how much oxygen is carried by the blood as a percentage of its full capacity. Ideally oxygen level in the body should be 95 and above. However, in COVID-19, as the disease sometimes causes lung fibrosis and breathing problem, the oxygen level decreases. In such cases oxygen therapy is given. Oxygen concentrators are machines which are available with different capacities of oxygen. The machine separates the nitrogen and the oxygen by adsorption on zeolites. It takes oxygen from the atmosphere and supplies pure oxygen as its output.



(a) Flow Meter Adjusting Valve (b) Pressure Regulator (c) Product tank (d) Molecular Sieve Beds
 (e) Surge tank (f) Heat Exchanger (g) Motor and compressor (h) Four Way Selenoid Valve (i) Air Enters (j) Nitrogen (k) Oxygen (l) Pure Oxygen

Theory

- 4.1** If air contains 21% of oxygen, how much air should the machine suck in order to get an oxygen supply of 1lit/min for 15 min each, 4 times a day? (0.5pt)

The other types of oxygen generators dissociate acidified water by use of electricity and give out oxygen.

- 4.2** To get 1lit/min for 15 min 4 times a day, how much water should be poured in the machine? (Assume complete electrolysis). (0.5pt)

A patient living at the seashore, requires a constant supply of medical oxygen through a nasal canula at the rate of 5 L/min. He has just got a new oxygen cylinder of capacity 340 L containing oxygen at pressure of 13700 kPa.

- 4.3** After how many days will he need to replace his oxygen cylinder? (0.5pt)

A person needs to supply dry ice for the storage of vaccine. The dry ice on sublimation occupies 2840 L at the ambient 30° C and 1 atm.

- 4.4** If this dry ice is to be obtained from limestone having 80 % $CaCO_3$ content, how much limestone will be required? What is the total kinetic energy (in kJ) of these gaseous molecules? (1.5pt)
You can assume that the gas behaves ideally.

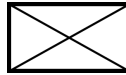
- 4.5** How much oxygen (in L at 30°C and 1 atm) would be needed for complete combustion of 1 mole of glucose ($C_6H_{12}O_6$)? What is the weight of oxygen required? (1.0pt)

The time taken for a certain volume of oxygen to diffuse through a small hole is 1 hour.

- 4.6** Calculate the time taken, in seconds, by the same volume of carbon dioxide and chlorine to diffuse through the same hole. (1.0pt)

General Instructions :

1. Only the answers marked or written in the answer sheet will be evaluated.
2. Instruction to mark a column with a cross (X) as an answer is to be marked as follows:



Please read the general instructions in the separate envelope before you start this problem.

Q.5. Date palm (6.75 points)

The date palm (*Phoenix dactylifera* L.) tree is a common sight in the Arabian Peninsula. Its fruits are eaten all over the world and are called dates.

Figure 5.1 represents a longitudinal section of the date fruit. Table 5.1 lists a set of tissues found in fruits.

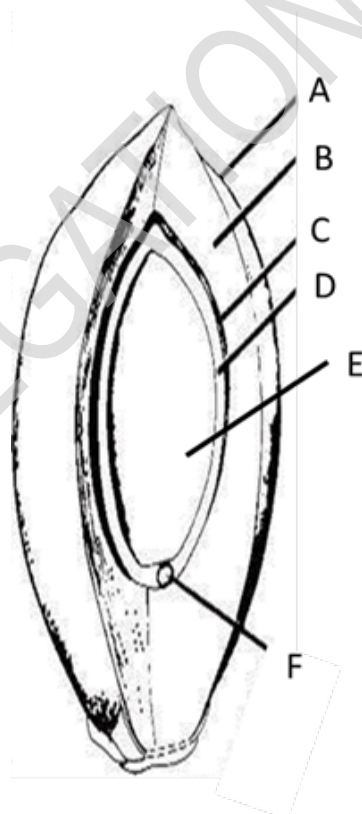


Figure 5.1. Longitudinal section of date fruit and seed.

No.	Tissue
1	Testa
2	Endocarp
3	Epicarp
4	Mesocarp
5	Embryo
6	Endosperm

Table 5.1

5.1. Match the tissues mentioned in Table 5.1 with the letters in Figure 5.1.

A.5.1 Mark a cross (X) in the appropriate column corresponding to each of the labels (A to E). As an example label F has been already marked in the table below. (0.5pt)

	Tissues					
Label	1	2	3	4	5	6
A						
B						
C						
D						
E						
F					X	

5.2. From the tissues (1-6) mentioned in Table 5.1, which tissues are derived only from the female parent?

A.5.2 Mark a cross (X) in the appropriate column (Yes/No) corresponding to each of (0.25pt) the tissues.

Tissue	Yes	No
1		
2		
3		
4		
5		
6		

5.3. During ripening, the date fruits show changes in the starch and sugar content as shown in the plot below (Figure 5.2).

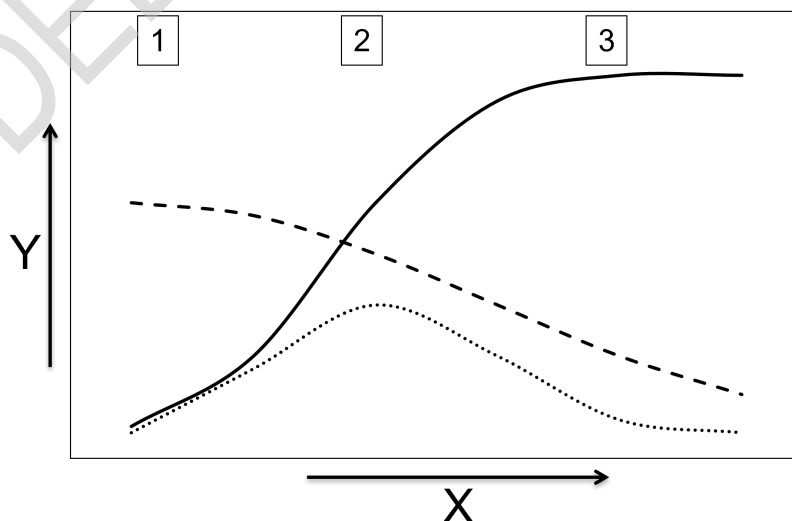


Figure 5.2

Theory

X	Days of fruit ripening
Y	% content
————	Total sugars
— —	Starch
....	Sucrose
1, 2, and 3	Stages of fruit ripening

Sucrose is synthesized in the leaves and transported to the fruit. In the fruit, sucrose is broken down into glucose and fructose by an enzyme A. Sugars are also formed by the breakdown of starch by enzyme B in the developing fruit. Total sugars include both mono- and di-saccharides.

The following statements were made:

Statement 1: The activity of enzyme B contributes to an increase in total sugars at stage 2.

Statement 2: The activity of enzyme A is higher at stage 1 than at stage 2.

Statement 3: The activity of both enzyme A and B is higher in the period between stage 2 and 3 than at stage 1.

Based on the analysis of the plot (Figure 5.2), are the above statements (1 to 3) correct?

A.5.3 Mark a cross (X) in the appropriate column (Yes/No) corresponding to each of the statements. (1.0pt)

Statement	Yes	No
1		
2		
3		

5.4. Invertase enzyme converts sucrose (disaccharide) to glucose and fructose (monosaccharides). One of the methods of estimating invertase activity is by measuring the level of glucose formed, using the glucose oxidase peroxidase method. In this method, the amount of glucose is estimated as the absorbance of the end product measured at 562 nm (A_{562}). A standard plot of A_{562} for different glucose concentrations as measured by the glucose oxidase peroxidase method is presented in Figure 5.3.

Theory

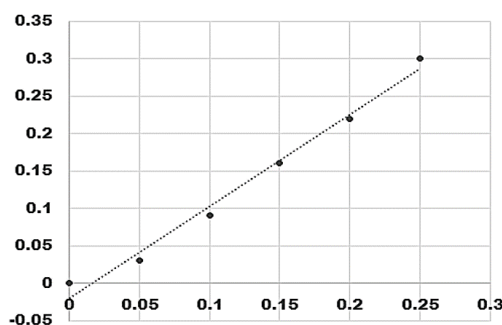


Figure 5.3. X = Glucose concentration (mg/ml); Y = A_{562}

Invertase activity is denoted in terms of enzyme units (U). One U invertase is defined as the amount of enzyme that will produce 1 μmol of glucose in 1 min at 30°C

In an experiment, the following reaction was set up to measure invertase activity:

i. 0.6 ml of buffer

ii. 0.2 ml of 400 mM sucrose

iii. 0.2 ml of invertase enzyme stock

- The reaction mixture was incubated at 30°C for 30 min, after which the reaction was stopped, by increasing the temperature.
- Glucose formed at the end of the reaction was estimated by glucose oxidase peroxidase method, and A_{562} was recorded.
- A_{562} was observed to be 0.1.

Based on the above information, answer the following questions:

Calculate the amount of sucrose in terms of μmoles that was present in the reaction mixture.

A.5.4.1 Amount of sucrose =

(0.5pt)

Based on the observed absorbance, what was the concentration of glucose (mg/ml) formed at the end of the reaction?

A.5.4.2

Concentration (mg/ml) of Glucose =

(0.25pt)

Calculate the amount of glucose in μmoles that was formed at the end of the reaction (M.W. of glucose = 180). Write your answer to 3 decimal points.

A.5.4.3

Amount of Glucose =

(0.75pt)

Calculate the invertase activity as U/ml of the invertase enzyme stock. Write your answer to 3 decimal points.

A.5.4.4

Invertase activity =

(1.5pt)

5.5. A researcher purified invertase from 1 kg of de-seeded date fruits. These fruits were homogenized in a suitable buffer and filtered using 4 layers of muslin cloth to obtain a crude extract. The crude extract was subsequently fractionated through a series of protein purification steps to enrich the invertase enzyme. Purification steps were designed to remove contaminating proteins with minimum loss of enzyme activity.

These steps involved (i) protein precipitation with $(NH_4)_2SO_4$, (ii) affinity column chromatography and (iii) anion exchange chromatography in a sequential manner. Invertase activity (U) and the protein content (mg) were measured at each step of purification. Also, (i) specific activity of enzyme and, (ii) % recovery were calculated at each step to assess the purification efficiency.

A step which removes the maximum amount of contaminating proteins with minimum loss in enzyme activity is considered as an efficient purification step.

- Specific activity of invertase is calculated as the enzyme activity per mg protein (U/mg).
- The % recovery can be represented as the percent of invertase activity (U) recovered after each step of purification in comparison to that of the crude extract.

Table 5.2 records the invertase activity and total protein in crude extract (step 1) and that recovered after different steps (2 to 4) of purification.

Calculate the specific activity of invertase at steps 1 to 4 and the % recovery for steps 2 to 4. Record your answer (to 3 decimals) in Table 5.2:

A.5.5.1

(1.0pt)

Table 5.2					
Step Number	Purification step	Invertase activity (U)	Total protein (mg)	Specific activity of invertase	% recovery of invertase
1	Crude extract	13,773	13,746		
2	Ammonium sulphate precipitation	12,469	8,234		
3	Affinity chromatography	11,487	836		
4	Anion exchange chromatography	11,156	567		

Based on the information given in Table 5.2, answer the following questions:

A.5.5.2 Identify the step number (1 to 4) that led to the most efficient purification of invertase by marking a cross (X) in the appropriate box. (0.5pt)

Steps	1	2	3	4

It is observed that there is a loss of an enzyme activity during different steps of purification.

A.5.5.3 Identify the step where there is maximum loss in the enzyme activity, by marking a cross (X) in the appropriate box. (0.5pt)

Steps	1	2	3	4

Q.6. Theory II – Bird populations (3.25 points)

A **population** is a group of individuals of the same species that live in the same area and interbreed, producing fertile offspring. The population's genetic makeup is characterized by describing its **gene pool**, which consists of all copies of every type of allele at every locus in all the members of the population. If only one allele exists for a particular gene in a population, that allele is said to be fixed in the gene pool. If there are two or more alleles for a particular gene in a population, individuals may be either homozygous or heterozygous.

The frequency of different alleles in a population is presented as the number of that allele present out of the total number of alleles for a given gene. For example, a population has 1000 copies of alleles for a given gene. If one of the alleles (X) of this gene has 100 copies the frequency of allele X is 0.1.

If a population is not evolving, the frequency of alleles will remain constant generation after generation. Such a population is said to be in equilibrium, as defined by Hardy and Weinberg; hence called Hardy-Weinberg equilibrium.

Scientists studied a population of 10,000 birds in a forest area. This **parental population** has birds with red, pink or white beaks. Mating between birds with red and white beaks leads to a progeny with birds with red, white and pink beaks in a ratio of 1: 1: 2. Beak color is governed by two alleles, B^R and B^W .

Which of the following can describe the relationship between the alleles B^R and B^W ? Mark a cross (X) in the appropriate columns marked, Yes/No.

A.6.1

(0.25pt)

S.No.	Relationship	Yes	No
1.	Co-dominance		
2.	Incomplete dominance		
3.	Over dominance		
4.	Dominant-recessive		

6.2. A DNA-based test was carried out to identify the genotypes of all the 10,000 birds in the above population. The observation is summarised in Table 6.1:

Theory

Phenotype	Genotype	Number of birds
Red beak	$B^R B^R$	6400
Pink beak	$B^R B^W$	3200
White beak	$B^W B^W$	400

Table 6.1

What is the frequency of the alleles B^R and B^W ?

A.6.2 Frequency of B^R =

(0.5pt)

Frequency of B^W =

6.3. All the birds in the parental population were tagged. After 6 months, the scientists visited the population and observed that 5,000 new chicks were born (Generation I). Observation following analysis of generation I is summarised in Table 6.2:

Phenotype	Genotype	Number of birds
Red beak	$B^R B^R$	3200
Pink beak	$B^R B^W$	1600
White beak	$B^W B^W$	200

Table 6.2

Based on comparing the observations in Table 6.1 and 6.2, the following statements were made:

Statement 1: The frequency of B^R and B^W alleles is the same in generation 1 and the parental population.

Statement 2: Random mating occurred in the parental population.

Statement 3: The population is not evolving.

Are the above statements (1 to 3) correct?

A.6.3 Mark a cross (X) in the appropriate column (Yes/No) corresponding to each of the statements. (0.5pt)

Statement	Yes	No
1		
2		
3		

Theory

6.4. 1000 chicks of generation I were transferred to an island before they matured to reproduce (were able to produce gametes). Of the 1000 chicks, 336 birds had red beaks, 504 birds had pink beaks and 160 birds had white beaks. Further, in the island it was observed that birds with white beaks were infertile. Random mating in this population led to 100 newborn chicks.

Calculate the number of chicks expected to have either (i) red beaks or (ii) pink beaks.

A.6.4 6.4.1. Red beak =

(1.5pt)

6.4.2. Pink beak =

Under the situation described in question 6.4, would the B^R allele be fixed in the population after 50 generations of random mating? Assume no new mutations occur for this gene.

A.6.5 Mark a cross (X) in the appropriate column marked **Yes/No**.

(0.25pt)

Yes	No
☐	☐

Which of the following conditions are essential for a population to be in Hardy-Weinberg equilibrium?

A.6.6 Mark a cross (X) in the appropriate columns marked **Yes/ No**.

(0.25pt)

S.No.	Condition	Yes	No
1.	Occurrence of mutations	☐	☐
2.	No gene flow	☐	☐
3.	Random mating	☐	☐
4.	Natural selection	☐	☐
5.	Small population size	☐	☐