



# Formula One

## IJSO Theory Mock Test

### Answer Sheet

#### Question 1 — Physics behind Formula One (10.00 points)

**Part A – Corners (2.30 points)**

A1. Find the radius of the racing line in terms of X, d, and r.

(1.00 points)

**Calculation:**





A2. Find the maximum velocity the car can have if the radius of the turn is 50m.

(0.50 points)

**Calculation:**



$$v_{\max} =$$

A3. Find the maximum velocity at this corner.

(0.80 points)

**Calculation:**



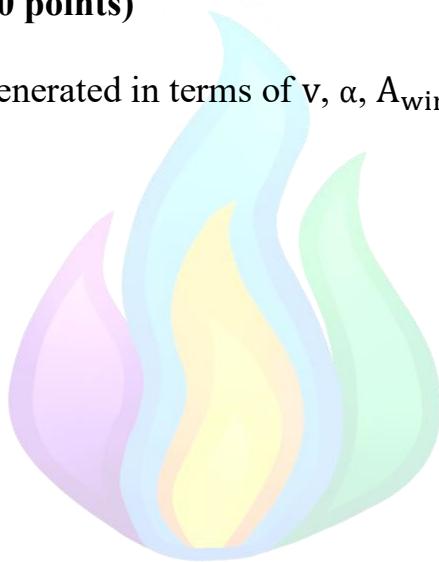
$v_{max} =$

**Part B – Downforce (1.00 points)**

B1. Find the downforce generated in terms of  $v$ ,  $\alpha$ ,  $A_{wing}$  and  $\rho_{air}$ .

(0.50 points)

**Calculation:**



B2. Find the new maximum velocity for part A2.

(0.50 points)

**Calculation:**



$v_{max} =$

**Part C – Straights (1.00 points)**

C1. Find the total resistive force against an F1 car travelling at a velocity  $v$  assuming no wind speed.

(0.40 points)

**Calculation:**



C2. Write a cubic equation (but do not solve) about the maximum velocity of an F1 car in a straight.

(0.60 points)

**Calculation:**



**Part D – Halo (1.50 points)**

D1. Calculate the average impact force on the driver's head.

(0.40 points)

**Calculation:**



$F =$

D2. Is this force survivable, knowing that forces above  $5 \cdot 10^4$  N are fatal.

- Yes
- No

(0.10 points)

D3. Calculate the component of the spring's momentum along the driver's head direction before and after hitting the Halo.

(0.50 points)

**Calculation:**



$p_1 =$

D4. Estimate by what percentage the Halo reduced the effective impulse on Massa's head.

(0.20 points)

**Calculation:**

Impulse =

D5. Which of the following properties of the triangular shape of the halo help resist bending?

- The triangular shape distributes impact forces along multiple load paths.
- Triangles are inherently rigid, preventing shape deformation under torque.
- The shape allows the Halo to absorb energy through large elastic stretching.
- The triangle minimizes the material needed while maximizing strength.
- Triangles bend easily under off-center impacts, reducing peak forces on the driver.
- The triangular shape converts bending torque into compressive and tensile forces along its members.

(0.30 points)

**Part E – Pit Stops (0.70 points)**

E1. Find the force  $F_1$  a mechanic needs to apply on the small piston to lift the car.

(0.30 points)

**Calculation:**

$$F =$$

E2. Calculate how high the car rises.

(0.40 points)

**Calculation:**



$$D =$$

**Part F – Light (1.00 points)**

F1. Find the image distance  $v$

(0.30 points)

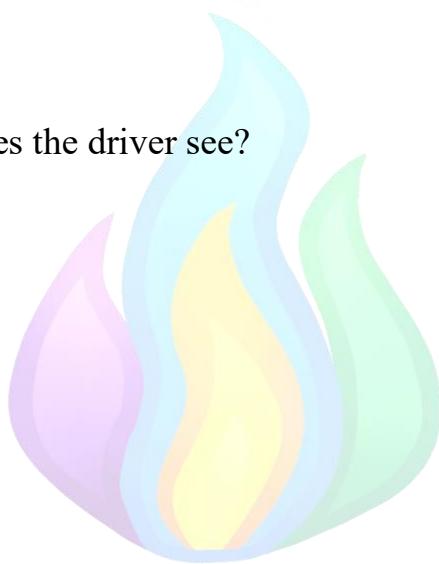
**Calculation:**

$v =$

F2. What image width does the driver see?

(0.30 points)

**Calculation:**



$l =$

F3. Find the maximum visible distance  $x_{\max}$ .

(0.40 points)

**Calculation:**

$x_{\max} =$

### **Part G – Thermodynamics (1.00 points)**

G1. Calculate the maximum theoretical efficiency of the engine.

(0.40 points)

**Calculation:**

$\eta =$

G2. Estimate the total energy emitted in one lap by the tire.

(0.60 points)

**Calculation:**

E =

**Part H – Sound (1.50 points)**

H1. Find the frequency when the car is travelling towards the microphone, moving away from the microphone, and just when passing by the microphone.

(1.10 points)

**Calculation:**



When the car is moving towards the microphone:  $f' =$

When the car is moving away from the microphone:  $f' =$

When the car is just passing by the microphone,  $f' =$

H2. What is the sound intensity  $I$  at a distance of  $r = 20\text{m}$  from the car?

(0.40 points)

**Calculation:**

L =

**Extra Space for Problem 1:**





## **Question 2 — Chemistry behind Formula One (10.00 points)**

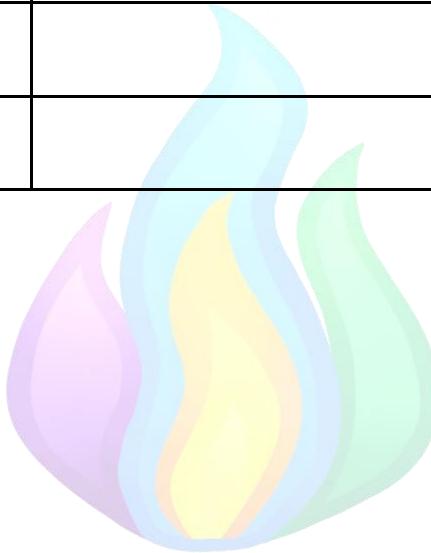
### **Part A – Fuel Combustion (3.50 points)**

A1. Write balanced chemical equations for the combustion of all compounds when excess oxygen is present.

(0.50 points)

**Calculation:**

Compound	Balanced Combustion reaction
Octane	
Cyclohexane	
Toluene	
1-hexene	
Ethanol	



A2. Fill the Kekulé structure of benzene with the hydrogen atoms required.

(0.25 points)

**Calculation:**



A3. Find the weight of the fuel needed for 1 lap?

(1.50 points)

**Calculation:**



$m =$

A4. Calculate the total amount of  $\text{CO}_2$  produced in one lap.

(0.50 points)

**Calculation:**



$$m = 19.52 \text{ kg}$$

A5. Find the mass percent composition of the exhaust gas mixture.

(0.75 points)

**Calculation:**



$\%_{CO} =$

$\%_{CO_2} =$

**Part B – Paint (3.50 points)**

B1. Indicate the chemical formulas of compounds A, B, C and D.

(0.80 points)

**Calculation:**

A =

B =

C =

D =

B2. Write the balanced equation for the last reaction.

(0.75 points)

**Calculation:**



B3. What are the smallest integer values for x and y?

(1.75 points)

**Calculation:**

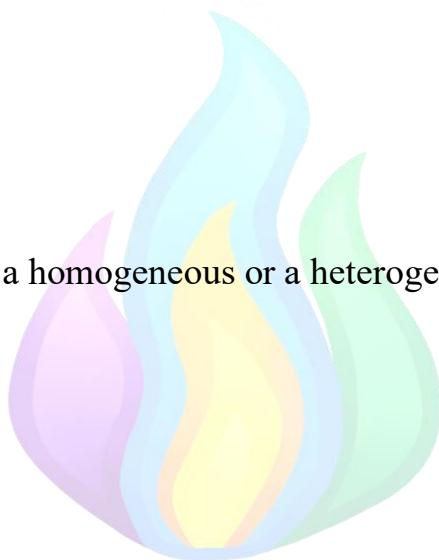


X =

Y =

B4. Is the paint described a homogeneous or a heterogenous system?

(0.20 points)



**Part C – Cooling Fluids (1.50 points)**

C1. Calculate the molality of the coolant

(0.30 points)

**Calculation:**

Molality =

C2. Using the approximate formula, find the temperature (Celsius) at which the coolant freezes.

(0.30 points)

**Calculation:**



New  $T_f$

C3. Find the exact temperature at which the coolant freezes, using the exact formula.

(0.30 points)

**Calculation:**

New  $T_f$

C4. Is using the approximate formula justified?

(0.30 points)

- Yes
- No

C5. It is known that the latent heat of fusion of ethylene glycol is  $L = 160 \text{ kJ/kg}$ . Find the enthalpy of fusion for ethylene glycol.

(0.30 points)

**Calculation:**



Enthalpy of fusion =

**Part D – Tires (1.50 points)**

D1. Calculate the number of moles of nitrogen in the tire and the mass of nitrogen

(0.50 points)

**Calculation:**

$n =$

mass =

D2. Find the new pressure  $P_2$  inside the tyre (in atm).

(0.50 points)

**Calculation:**



$P_2 =$

D3. Calculate the new pressure  $P_3$ . Give the pressure drop  $P_2 - P_3$  in atm.

(0.50 points)

**Calculation:**

$$P_2 - P_3 =$$

**Extra space for problem 2:**





### **Question 3 — Biology behind Formula One (10.00 points)**

#### **Part A – Adrenaline (3.00 points)**

A1. Tick the correct answers.

- Increases heart rate and blood pressure to enhance oxygen and nutrient delivery to skeletal muscle and the brain.
- Dilates most arterioles in the skin and digestive tract while constricting those in skeletal muscle.
- Causes bronchial smooth muscle relaxation, increasing airflow to the lungs.
- Stimulates glycogenolysis and lipolysis, raising blood glucose and fatty acid

levels.

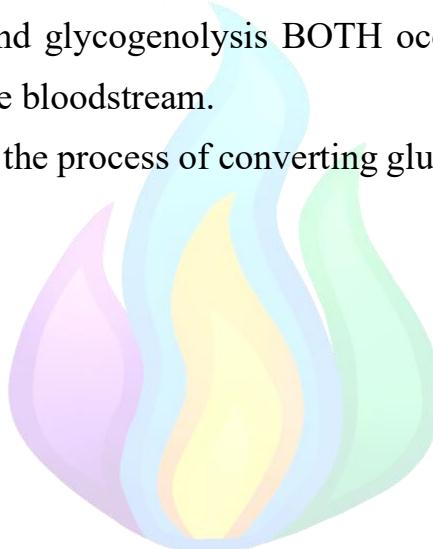
- Constricts pupils to reduce glare under bright track lights.

(0.75 points)

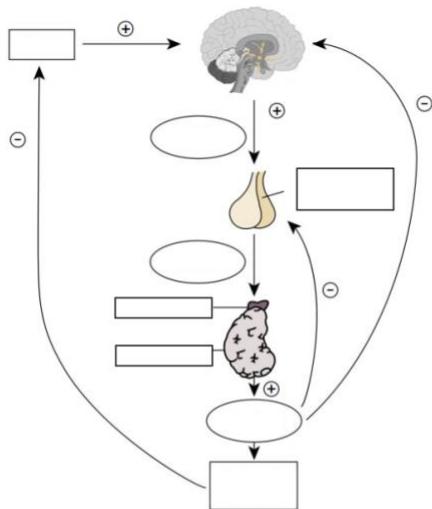
A2. Select the correct option with regards to what leads to this glucose increase:

- A. Only gluconeogenesis, the process of creating glucose from precursors like lactate, glycerol, or amino acids leads to the increase in glucose levels.
- B. Only glycogenolysis, the process of converting glycogen (converting energy) into glucose (usable energy).
- C. Gluconeogenesis and glycogenolysis BOTH occur to substantially increase glucose levels in the bloodstream.
- D. Only glycogenesis, the process of converting glucose to glycogen and storing it in the liver.

(0.50 points)



A3. Fill in the blanks using the word bank below:

**Word Bank:**

Stress    Hypothalamus    Cortisol    ACTH  
 Metabolic Effects    Anterior Pituitary  
 Adrenal Gland    CRH    Kidney

(0.75 points)

A4. Which of the following options are incorrect with regards to how reflexes are triggered and executed?

- A. Simple reflexes do not require direct brain involvement, most of them are mediated at the spinal cord - speeding up response time.
- B. Adrenaline causes reflexes by increasing neuronal conduction velocity via production of more oligodendrocytes that produce myelin.
- C. Heightened reflexes occur under adrenaline partially because of the simultaneous release of excitatory neurotransmitters increasing neural activity.
- D. Reflex arcs involve a sensory receptor, sensory neuron, motor neuron, and possibly interneuron.

(1.00 points)

**Part B – Studying the surrounding ecosystem (4.50 points)**

B1. Calculate and select the correct approximate Shannon Index for this community:

- A. 0.23
- B. 0.36
- C. 1.34**
- D. 2.00

(1.00 points)

**Calculation:**



B2. Calculate the maximum possible diversity in the Albert Park community.

(0.40 points)

**Calculation:**



$H_{max} =$

B3. What is the evenness index of this community?

(0.40 points)

**Calculation:**

Evenness index =

B4. a) Recalculate the Shannon index for the remaining three species.

(0.60 points)

**Calculation:**



b) The Shannon index increased/remained the same/decreased

(0.20 points)

c) The maximum possible diversity increased/remained the same/decreased.

(0.20 points)

**Calculation:**

$$H_{\max} =$$

B5. Does the diversity index increase, remain the same, or decrease?

(0.50 points)

**Calculation:**



The diversity index increased, remained the same, or decreased.

B6. Using the original proportions, calculate the Simpson's Index

(0.75 points)

**Calculation:**



D =

B7.

a. Which index is more sensitive to rare species?

Shannon index / Simpson index

(0.15 points)

b. Which index is more influenced by the most abundant species?

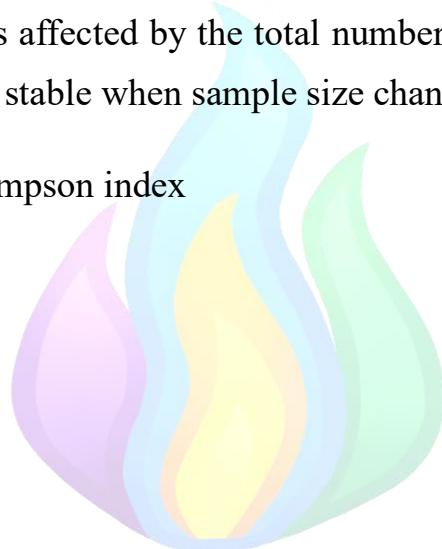
Shannon index / Simpson index

(0.15 points)

c. Which index is less affected by the total number of individuals sampled (N) and therefore more stable when sample size changes?

Shannon index / Simpson index

(0.15 points)



### Part C – The ecological effects of racing (2.50 points)

C1. Which hormone is most disrupted?

- A. Thyroxine
- B. Cortisol
- C. Melatonin
- D. Dopamine

(0.15 points)

C2. Which biological rhythm is most disturbed?

- A. Annual biological rhythm
- B. Daily circadian rhythm
- C. Lunar tidal rhythm
- D. Seasonal photoperiodism

(0.15 points)

C3. Which structure is blocked first, limiting gas exchange?

- A. Xylem
- B. Stomata
- C. Guard cells
- D. Root hairs

(0.15 points)

C4. This process of increasing concentration across trophic levels is called:

- A. Eutrophication
- B. Bioaccumulation
- C. Biomagnification
- D. Bioremediation

(0.15 points)

C5. State whether they are at risk by circling one of the options:

Yes, at risk / No, not at risk

(0.75 points)

**Calculation:**



C6. Which immediate plant response is most likely?

- A. Reduced leaf surface area
- B. Increased growth from extra nutrients
- C. Reduced root length
- D. Chlorophyll breakdown

(0.25 points)

C7. In high doses, zinc interferes with enzyme function by binding to:

- A. Active sites of proteins
- B. Sulfhydryl groups of amino acids
- C. Ribosomal RNA in cytoplasm
- D. Phospholipid bilayers of cell membranes

(0.50 points)

C8. Ozone primarily damages plants by:

- A. Causing oxidative stress in leaf cell membranes
- B. Inhibiting stomatal opening and closing
- C. Mutating nuclear DNA of guard cells
- D. Blocking phloem transport of sugars

(0.25 points)

C9. What is the first biological response in the aquatic ecosystem?

- A. Rapid growth of algae and cyanobacteria
- B. Decline in dissolved oxygen
- C. Fish mortality
- D. Increase in decomposer activity

(0.15 points)

**Extra space for problem 3:**

