Formula One 🏎️

IJSO MCQ mock test

This is an IJSO mock test, a paper made to mimic the style and difficulty of IJSO questions. Its aim is to help students in preparing for the IJSO and IJSO like competitions.

The questions in this paper were made by the following members of our team (in alphabetical order):

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In solving the questions, you might need to use the following constants:

Constant	Notation	Value
Acceleration due to gravity	g	$9.8\ ms^{-2}$
Gravitational constant	G	$6.67 \cdot 10^{-11}\ m^3/\ kg \cdot s^2$
Planck's constant	h	$6.62 \cdot 10^{-34}\ J \cdot s$
Elementary charge	e	$1.6 \cdot 10^{-19}\ C$
Speed of light in vacuum	c	$3 \cdot 10^8\ ms^{-1}$
Density of water	ρ	$1000\ kg\ m^{-3}$
Stefan-Boltzmann constant	σ	$5.67 \cdot 10^{-8}\ \frac{W}{m^2K^4}$
Universal gas constant	R	$8.314\ J\ mol^{-1}\ K^{-1}$ $0.0821\ atm\ L\ mol^{-1}\ K^{-1}$
Avogadro's number	N_A	$6.022 \cdot 10^{23}\ mol^{-1}$
Faraday's constant	F	96 500 C/mol
Pi	π	3.14
Electrical permittivity of free space	ε_0	$8.85 \cdot 10^{-12}\ F \cdot m^{-1}$
Magnetic permeability of free space	μ_0	$4\pi \cdot 10^{-7}\ H/m$
Mass of Earth		$5.97 \cdot 10^{24}\ kg$
Mass of Moon		$7.35 \cdot 10^{22}\ kg$
Mass of Sun		$1.99 \cdot 10^{30}\ kg$
Radius of Earth		$6.4 \cdot 10^6\ km$
Radius of Moon		$1.7 \cdot 10^6\ km$
Radius of Sun		$6.96 \cdot 10^8\ km$
Specific heat capacity of water	c_w	$4200\ J/kg \cdot °C$
Average molar mass of air	M	28.9 g/mol

If any other value is provided in the problem, use the value provided, not the one in the table. You can also use the following conversion formulas:

$T\ (K) = t\ (°C) + 273$	$t\ (°F) = \frac{9}{5} t\ (°C) + 32$
$1bar = 1atm = 101\ 000Pa = 760mmHg$	$1u = 1Da = 1.66 \cdot 10^{-27} kg$
$1L = 10^{-3}\ m^3$	$1\ day = 24h$

If needed, you can use the periodic table given bellow:

(Use atomic masses rounded to two decimal places.)

IUPAC Periodic Table of the Elements

Key: atomic number / Symbol / name / abridged standard atomic weight

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H hydrogen 1.0080 ± 0.0002																	2 He helium 4.0026 ± 0.0001
3 Li lithium 6.94 ± 0.06	4 Be beryllium 9.0122 ± 0.0001											5 B boron 10.81 ± 0.02	6 C carbon 12.011 ± 0.002	7 N nitrogen 14.007 ± 0.001	8 O oxygen 15.999 ± 0.001	9 F fluorine 18.998 ± 0.001	10 Ne neon 20.180 ± 0.001
11 Na sodium 22.990 ± 0.001	12 Mg magnesium 24.305 ± 0.002											13 Al aluminium 26.982 ± 0.001	14 Si silicon 28.085 ± 0.001	15 P phosphorus 30.974 ± 0.001	16 S sulfur 32.06 ± 0.02	17 Cl chlorine 35.45 ± 0.01	18 Ar argon 39.95 ± 0.16
19 K potassium 39.098 ± 0.001	20 Ca calcium 40.078 ± 0.004	21 Sc scandium 44.956 ± 0.001	22 Ti titanium 47.867 ± 0.001	23 V vanadium 50.942 ± 0.001	24 Cr chromium 51.996 ± 0.001	25 Mn manganese 54.938 ± 0.001	26 Fe iron 55.845 ± 0.002	27 Co cobalt 58.933 ± 0.001	28 Ni nickel 58.693 ± 0.001	29 Cu copper 63.546 ± 0.003	30 Zn zinc 65.38 ± 0.02	31 Ga gallium 69.723 ± 0.001	32 Ge germanium 72.630 ± 0.008	33 As arsenic 74.922 ± 0.001	34 Se selenium 78.971 ± 0.008	35 Br bromine 79.904 ± 0.003	36 Kr krypton 83.798 ± 0.002
37 Rb rubidium 85.468 ± 0.001	38 Sr strontium 87.62 ± 0.01	39 Y yttrium 88.906 ± 0.001	40 Zr zirconium 91.224 ± 0.002	41 Nb niobium 92.906 ± 0.001	42 Mo molybdenum 95.95 ± 0.01	43 Tc technetium [97]	44 Ru ruthenium 101.07 ± 0.02	45 Rh rhodium 102.91 ± 0.01	46 Pd palladium 106.42 ± 0.01	47 Ag silver 107.87 ± 0.01	48 Cd cadmium 112.41 ± 0.01	49 In indium 114.82 ± 0.01	50 Sn tin 118.71 ± 0.01	51 Sb antimony 121.76 ± 0.01	52 Te tellurium 127.60 ± 0.03	53 I iodine 126.90 ± 0.01	54 Xe xenon 131.29 ± 0.01
55 Cs caesium 132.91 ± 0.01	56 Ba barium 137.33 ± 0.01	57-71 lanthanoids	72 Hf hafnium 178.49 ± 0.01	73 Ta tantalum 180.95 ± 0.01	74 W tungsten 183.84 ± 0.01	75 Re rhenium 186.21 ± 0.01	76 Os osmium 190.23 ± 0.03	77 Ir iridium 192.22 ± 0.01	78 Pt platinum 195.08 ± 0.02	79 Au gold 196.97 ± 0.01	80 Hg mercury 200.59 ± 0.01	81 Tl thallium 204.38 ± 0.01	82 Pb lead 207.2 ± 1.1	83 Bi bismuth 208.98 ± 0.01	84 Po polonium [209]	85 At astatine [210]	86 Rn radon [222]
87 Fr francium [223]	88 Ra radium [226]	89-103 actinoids	104 Rf rutherfordium [267]	105 Db dubnium [268]	106 Sg seaborgium [269]	107 Bh bohrium [270]	108 Hs hassium [269]	109 Mt meitnerium [277]	110 Ds darmstadtium [281]	111 Rg roentgenium [282]	112 Cn copernicium [285]	113 Nh nihonium [286]	114 Fl flerovium [290]	115 Mc moscovium [290]	116 Lv livermorium [293]	117 Ts tennessine [294]	118 Og oganesson [294]

57 La lanthanum 138.91 ± 0.01	58 Ce cerium 140.12 ± 0.01	59 Pr praseodymium 140.91 ± 0.01	60 Nd neodymium 144.24 ± 0.01	61 Pm promethium [145]	62 Sm samarium 150.36 ± 0.02	63 Eu europium 151.96 ± 0.01	64 Gd gadolinium 157.25 ± 0.03	65 Tb terbium 158.93 ± 0.01	66 Dy dysprosium 162.50 ± 0.01	67 Ho holmium 164.93 ± 0.01	68 Er erbium 167.26 ± 0.01	69 Tm thulium 168.93 ± 0.01	70 Yb ytterbium 173.05 ± 0.02	71 Lu lutetium 174.97 ± 0.01
89 Ac actinium [227]	90 Th thorium 232.04 ± 0.01	91 Pa protactinium 231.04 ± 0.01	92 U uranium 238.03 ± 0.01	93 Np neptunium [237]	94 Pu plutonium [244]	95 Am americium [243]	96 Cm curium [247]	97 Bk berkelium [247]	98 Cf californium [251]	99 Es einsteinium [252]	100 Fm fermium [257]	101 Md mendelevium [258]	102 No nobelium [259]	103 Lr lawrencium [262]

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For notes and updates to this table, see www.iupac.org. This version is dated 4 May 2022.

Question 01 – Braking Distance

The average human being has a reaction time of about 0.80 s, but an F1 driver's reaction time is around 0.20 s. During a race, a driver may spend roughly 0.15 s in one blink. At high speeds, this still means the car covers a certain distance in the "dark" — for example, it is found that the driver travels 13.5 m while blinking.

In a separate incident at the same speed, the driver suddenly spots a raccoon running across the track. Before braking, the driver first spends the full duration of their own reaction time processing the situation, and only then begins to brake. After reacting, the car continues moving forward until it eventually comes to a complete stop. Assuming the maximum deceleration of an F1 car to be 6g where g = acceleration due to gravity, find the total distance the car travels after the driver sees the raccoon.

A. 18.00 m
B. 54.49 m
C. 68.88 m
D. 86.88 m

Problem proposed by Thenura Wickramaratna

Question 02 – Oscillating Car

An F1 car weighs 800 kg. The weight is distributed among the 4 wheels. The suspension on one wheel can be modelled as a spring with spring constant $k = 1.20 \cdot 10^5\ Nm^{-1}$. Find the natural frequency f (in Hz) of small vertical oscillations of the car at that wheel. (Use $\omega = \sqrt{\frac{k}{m}}$)

A. 1.95 Hz
B. 3.90 Hz
C. 12.25 Hz
D. 24.49 Hz

Problem proposed by Thenura Wickramaratna

Question 03 – Spark Plug

The fuel in engines starts burning after an electric spark is generated in a component known as a spark plug. We can model the spark plug as a capacitor, with the dielectric being air, plate area $S = 1mm^2$ and the distance between the plates $d = 0.5mm$. The spark forms if the potential difference between the plates of the capacitor exceeds 300 V.

Let's consider an ideal battery with e.m.f. $E = 500$ V is connected to a spark plug and the total resistance of the connection wires is $R = 1$ kΩ. It can be shown that the charge on the capacitor's plates is:

$$Q(t) = CE(1 - e^{-\frac{t}{RC}})$$

Where $e = 2.71$, t is the time, and C, E and R are the capacitance, the e.m.f. and the total resistance respectively.

If the spark plug is uncharged and at $t = 0$ it is connected to the ideal battery, after how much time will the spark form?

A. $1.6 \cdot 10^{-11}$ s
B. $2.3 \cdot 10^{-11}$ s
C. $4.7 \cdot 10^{-11}$ s
D. $8.1 \cdot 10^{-11}$ s

Problem proposed by Alex Jicu

Question 04 – Forces acting on blood

Blood normally moves through the body under the influence of a number of forces, including valves in the blood vessel, gravity and compression from nearby muscles. In this problem let us only consider gravity and neglect forces of biophysical nature.

Consider an F1 driver who accelerates suddenly from rest with acceleration 2g on a horizontal track (g is the acceleration due to gravity). Because of the acceleration, his blood will experience an unnatural force, which will restrict blood flow. Although normally blood is pulled only vertically by gravity, now the direction changes due to the acceleration. What is the angle between the apparent force acting on the blood and the normal vertical direction, and what is its orientation relative to the driver (the driver is facing towards the direction in which the car is accelerating)?

A. $26.5°$ to the front
B. $26.5°$ to the back
C. $63.4°$ to the front
D. $63.4°$ to the back

Problem proposed by Alex Jicu

Question 05 – ERS System

In a Formula One car's Energy Recovery System (ERS), part of the stored electrical energy can be modelled as being held in a parallel-plate capacitor.

Two conducting plates of area $A = 0.20\ \mathrm{m}^2$ each are placed parallel to one another at a distance $d = 1.0\ \mathrm{mm}$. The space between them is filled with a dielectric material of relative permittivity $\epsilon_r = 5.0$.

The capacitor is charged to a potential difference of $V = 500\ \mathrm{V}$ before the driver presses the overtake button to release the stored energy.

What is the total energy stored in this capacitor?

A. $1.1 \cdot 10^{-3}\ \mathrm{J}$

B. $2.2 \cdot 10^{-3}\ \mathrm{J}$

C. $1.1 \cdot 10^{-2}\ \mathrm{J}$

D. $2.2 \cdot 10^{-3}\ \mathrm{J}$

Problem proposed by Jabir Abbasov

Question 06 – Rear-view Mirror

The rear-view mirror of an F1 car is a convex mirror with a focal length of - 0.3 m. If a car is approaching along the mirror's principal axis at a distance of 5 m, the image formed will be:

A. Real, inverted, smaller than the object
B. Virtual, upright, smaller than the object
C. Virtual, upright, same size as the object
D. Real, inverted, larger than the object

Problem proposed by Jabir Abbasov

Question 07 – Acceleration

An F1 driver is moving with $v_1 = 360\ \mathrm{km/h}$, with his car weighing $m_1 = 870\ \mathrm{kg}$ (total mass, driver included). He fails to notice another driver, who swerved in front of him, who is moving slower, with $v_2 = 300\ \mathrm{km/h}$ and with a mass of $m_2 = 950\ \mathrm{kg}$. Because of the abrupt maneuver of the second driver, the two drivers crash, with the collision being perfectly plastic (inelastic). The duration of the impact is approximately $\Delta t = 50$ ms. What is the acceleration due to the crash the first driver experienced, in terms of g (acceleration due to gravity):

A. 16.2 g
B. 17.8 g
C. 58.6 g
D. 63.9 g

Problem proposed by Alex Jicu

Question 08 – Accident

After an accident, an F1 driver was rushed to the hospital for investigations and treatment. Right after the crash, his heart rate was measured and was found to be raised above normal values. Following the accident, he has lost some blood which was analyzed and found to have two different kinds of blood group related antibodies. At the hospital, an X-ray scan was performed, and the most important fractures were: two broken phalanges and three broken ribs. Another crucial issue to be resolved is the assessment of any possible damage to the nervous system. Upon checking the patellar reflex, he didn't show the usual extension (knee jerk), but he told the doctors he can feel the hit as usual. Consider the following statements:

i. If the driver kept losing blood, he would have needed a transfusion; however, this wouldn't have been a big issue, as his blood group allows him to receive any kind of blood (considering only the ABO system)

ii. In total, he has 54 unbroken phalanges and 21 unbroken ribs

iii. At the site of the bleeding, some proteins called clotting factors help with the process called homeostasis, forming a stable clot which prevents blood loss

iv. His neurological symptoms are consistent with damage to one or more of the ascending nerves leading to the spine

v. After the crash, his heart rate was increased because of hormones released by the adrenal medulla, such as norepinephrine

Which of the statements are true?

A. i, iii, iv, v
B. i, iv, v
C. ii, iii, iv
D. ii, v

Problem proposed by Alex Jicu

Question 09 – Heat Absorbed

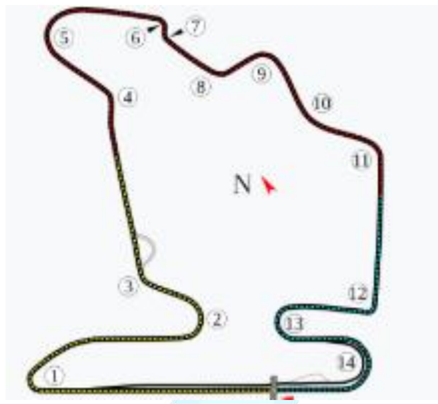
Air is 80% N_2 and 20% O_2 by volume. An air duct passes 400 L/s of air over the brakes. If the molar heat capacities at constant pressure are $C_P\ (N_2) = 29\ J/mol \cdot K$ and $C_P\ (O_2) = 30\ J/mol \cdot K$, how much heat can be absorbed per second if air enters at 300 K and exits at 310 K?

A. 3.54 kJ
B. 4.74 kJ
C. 6.12 kJ
D. 7.06 kJ

Problem proposed by Jabir Abbasov

Question 10 – Hungaroring Track Part 1

Formula one tracks are closed loops in which the drivers go in a circle-like (more or less) trajectory. For example, the picture below shows the Hungaroring track, in Budapest, where one of the races in this year's calendar was held:



In a race, 20 drivers compete, driving on the closed loop track, around the center. This is very similar to the Bohr model of the atom so we could draw an analogy between the two. Using this analogy, which of the following is true?

A. The track with the drivers can be compared to an atom with a mass number of 20
B. If one of the drivers did not finish (DNF), the track is similar to a potassium ion (when a driver DNFs, the car is removed from the track)
C. A driver closer to the inner edge of the track is similar to a lower energy electron, such as a 1s electron
D. If 2 drivers did not finish (DNF), the track is similar to a calcium divalent anion (when a driver DNFs, the car is removed from the track)

Problem proposed by Alex Jicu

Question 11 – Hungaroring Track Part 2

It is also known that on the Hungaroring track, drivers move clockwise. Using an analogy similar to the one before, treating the drivers as negative point-like charges and the track as a conducting loop, choose the correct statement:

A. The movement of the drivers would induce a magnetic field going downwards, towards the ground
B. If a magnet fell from the sky, with its North pole downwards, according to Lenz's law, it would make the drivers go faster
C. The current due to the moving drivers is clockwise
D. If the drivers were randomly distributed around the track, on average, due to electrostatic forces, they would be attracted to the center of the track (and this force would act as the centripetal force)

Problem proposed by Alex Jicu

Question 12 – Tire Pressure

A Formula One tire is inflated with pure nitrogen to a gauge pressure (relative to the atmosphere) of 21.0 psi at $20^\circ\mathrm{C}$. After several laps, the tire temperature rises to $100^\circ\mathrm{C}$. Assume the tire volume is constant and that nitrogen behaves as an ideal gas. Atmospheric pressure is 14.7 psi.

What is the new gauge pressure inside the tire (in psi)?

A. 24.1 psi
B. 26.7 psi
C. 28.5 psi
D. 30.7 psi

Problem proposed by Jabir Abbasov

Question 13 – Hydrazoic Acid

Nitrogen producing reactions are crucial for inflating the tires of F1 cars, as they are inflated mainly with hydrogen gas. One such reaction is the decomposition of the sodium salt of hydrazoic acid (HN_3) - compound X - into its constituent elements.

If temperature is T = 300K and the volume of a tire is 50L, what mass of compound X is required such that the nitrogen produced, once introduced in the tire, generates a pressure of 2atm? Consider an 80% nitrogen collection yield.

A. 110 g
B. 146 g
C. 176 g
D. 220 g

Problem proposed by Alex Jicu

Question 14 – ERS Battery

In Formula One, the Energy Recovery System (ERS) stores energy in a battery pack during braking and releases it during acceleration. Consider that the ERS battery is based on a lithium-ion cell, where the half-reactions are:

- At the anode (during discharge):

$$LiC_6 \rightarrow C_6 + Li^+ + e^-$$

- At the cathode (during discharge):

$$LiCoO_2 + Li^+ + e^- \rightarrow Li_2CoO_2$$

If a car recovers 200 kJ of energy and the average cell potential is 3.7 V, how many moles of electrons must pass through the external circuit to store this energy in the ERS battery?

A. 0.56 mol e^-
B. 0.90 mol e^-
C. 1.40 mol e^-
D. 2.10 mol e^-

Problem proposed by Thenura Wickramaratna

The following information is required for problems 15 and 16:

Some components of exhaust gases, such as NO or CO are harmful to the environment. Although F1 cars lack it, most cars have a catalytic converter - usually a noble metal which helps ease the oxidation of these partly oxidized compounds and decrease the danger. A group of scientists decide to analyze the effects of introducing catalytic converters to F1.

Let's analyze the oxidation of CO to CO_2 by a Pt catalytic converter. The way it works is gases entering nanometric holes on the surface of the metal and reacting there. We denote a free hole by σ and a hole occupied by an X molecule with X - σ. Carbon monoxide can be oxidized as follows:

$$CO + \frac{1}{2} O_2 \rightarrow CO_2 \qquad \Delta H_0$$

However, this process is quite inefficient. Instead, in the presence of the catalytic converter, the following process takes place:

$$CO + \sigma \rightarrow CO - \sigma \qquad \Delta H_1$$

$$\frac{1}{2} O_2 + \sigma \rightarrow O - \sigma \qquad \Delta H_2$$

$$CO - \sigma + O - \sigma \rightarrow CO_2 + 2\sigma \qquad \Delta H_3$$

Question 15 – Catalytic Converter Part 1

Which of the following statements about the oxidation in the presence of a catalytic converter is true:

A. The process promoted by the catalytic converter is more efficient because the sum $\Delta H_1 + \Delta H_2 + \Delta H_3 < \Delta H_0$

B. Catalytic converters have to be changed pretty often, as the free sites quickly get occupied by gases

C. The catalytic converter promoted process is energetically more inefficient ($\Delta H_1 + \Delta H_2 + \Delta H_3 > \Delta H_0$), but it's quicker and that's why it helps oxidizing the exhaust gas

D. As the process promoted by the catalytic converter is a multi-step process it is characterized by more activation energies; however, the sum of those energies is less than the one of the simple processes, leading to more efficient oxidation

Problem proposed by Alex Jicu

Question 16 – Catalytic Converter Part 2

Let's consider a car with average fuel composition 85% C and 15% H by mass. The car burns 0.1kg of fuel per minute. In the burning process, 40% of the carbon is burned completely (to CO_2) and 60% is oxidized only partially to CO. After the burning, the gas mixture passes over the catalytic converter and some of the CO gets fully oxidized to CO_2. In the final exhaust gas, the CO_2 output is 6 mol/min. Defining the catalytic efficiency as the percent of the CO that gets oxidized to CO_2, what is the catalytic efficiency of the given catalytic converter?

A. 47.2 %
B. 53.4 %
C. 72.0 %
D. 74.6 %

Problem proposed by Alex Jicu

Question 17 – Lactic Acid Production

During an F1 race, a driver's muscles produce lactic acid (HLac, $pK_a \approx 3.9$). Luckily, the blood is buffered by the lactate buffer system ($HLac/Lac^-$).

Suppose in a driver's blood, the ratio of $[Lac^-]$ to $[HLac]$ is 10:1. What is the approximate pH of the blood according to the Henderson–Hasselbalch equation?

A. 3.9
B. 4.9
C. 5.9
D. 6.9

Problem proposed by Jabir Abbasov

Question 18 – 7075 Aluminum

F1 cars are subjected to very high mechanical stress and choosing the right material for building the car is a very important task for F1 engineers. One alloy used in the building of F1 cars is 7075 Aluminum which has the following mass percent composition - 90% aluminum, 6% zinc, 2.5% magnesium, 1.5% copper.

If a 10g sample of 7075 Aluminum is submerged in excess hydrochloric acid. What amount (mol) of hydrogen is released after the completion of the reaction? Hint: to avoid rounding errors (due to the precision of the answer options), do intermediate calculations with 5 decimal places.

A. 0.3554
B. 0.3530
C. 0.5198
D. 0.5222

Problem proposed by Alex Jicu

Question 19 – Reaction Rates

The combustion of a hydrocarbon fuel in a Formula One engine cylinder follows the Arrhenius equation:

$$k = Ae^{-\frac{E_a}{RT}}$$

The reaction is zero order with respect to the fuel.

- At $T_1 = 800$ K, 0.50 mol of fuel reacts completely in 10.0 s.
- At $T_2 = 900$ K, 0.75 mol of fuel reacts completely in 8.0 s.

Assuming the amount of fuel reacted per unit time is directly proportional to the rate constant k, use this data to predict how many moles of fuel will react completely in 6.0 s at $T_3 = 950$ K.

A. 0.60 mol
B. 0.73 mol
C. 1.15 mol
D. 1.50 mol

Problem proposed by Thenura Wickramaratna

Question 20 – Equilibrium

Unburnt products, such as carbon monoxide, are far more dangerous than the completely burnt products (carbon dioxide), although both have their dangers. A method commonly used for oxidizing CO completely to CO_2 is reacting it with H_2O gas, which gets reduced to H_2. At the temperature of the reaction, the equilibrium constant is K = 1.60 and all products are in the gas phase.

At the same pressure and temperature, CO and H_2O gases are fed into a reactor at rates of 1 L/s and 1 L/s respectively and the resulting gas is collected. Assuming equilibrium is reached very quickly inside the reactor, at what rate is CO_2 gas collected?

A. 0.29 L/s
B. 0.31 L/s
C. 0.35 L/s
D. 0.56 L/s

Problem proposed by Alex Jicu

Question 21 – Hydrogen Combustion

Naturally, a vital part of F1 cars is their engine. To avoid any unfair advantages given by stronger engines, FIA has a number of technical requirements regulating the specifications of engines. These requirements are updated to keep up with the evolving engine industry and types of engines. Right now, F1 cars have a hybrid engine.

With research in different types of engines happening, one promising future type of engine is the hydrogen combustion based one, in which hydrogen is burnt in oxygen to produce water. The enthalpy of formation of water is -286 kJ/mol.

The power of an F1 engine has to be around 1000 horsepower (1hp = 745.7W) and a hydrogen combustion engine converts the released energy into mechanical energy with roughly an 80% yield.

What mass of hydrogen should an F1 car burn per minute to ensure enough power?

A. 158 g
B. 198 g
C. 317 g
D. 395 g

Problem proposed by Alex Jicu

Question 22 – Effects on the body

During an F1 race, a driver can experience decelerations when braking. Such high forces not only affect the car but also affect the driver's body.

During heavy braking, the driver's "apparent" body weight increases drastically due to G-forces. This impacts the body by drawing blood away from the head and towards the feet. To cope, F1 drivers undergo special physical training to strengthen neck and core muscles and must also maintain cardiovascular fitness to prevent loss of consciousness.

Which of the following is NOT a likely physiological effect of sustaining high rates of deceleration for a short duration?

A. Increased tingling, discomfort, and potential swelling in lower limbs due to stagnant lymphatic drainage and venous return.
B. Syncope (loss of consciousness) if cerebral oxygenation is inadequate
C. Risk of reduced vision or "blackout" due to lack of oxygen in retinal cells
D. Increased lung capacity due to higher air pressure inside the cockpit

Problem proposed by Thenura Wickramaratna and Josephine Ankomah

Question 23 – Evolution

Industrial melanism is an evolutionary effect commonly met after the industrial revolution. Processes which release unburnt fuels (hydrocarbons, sooth) effectively darken the environment, as the dark substances deposit on trees and on the ground. One problem of F1 cars is the fast burning of fuel which leads to high amounts of such substances being released. Over time, in areas where a lot of F1 races take place, this phenomenon can lead to the survival of darker individuals, which are camouflaged better, overall increasing the pigmentation of the species - this is known as industrial melanism. What is industrial melanism an example of?

A. Natural selection
B. Artificial selection
C. Selective breeding
D. Genetic drift

Problem proposed by Alex Jicu

Question 24 – Evolutionary Biology

Formula 1 teams are constantly working to improve their cars' performance under various pressures like safety, speed, combat, and aerodynamics. Likewise, living organisms undergo constant evolution to increase fitness and survival under changing environmental conditions.

Choose the correct analogies between F1 engineering and evolutionary biology:

i) A team starting with one basic car model and branching out to make two different models from that one is similar to homologous evolution.

ii) An F1 driver developing strong car control skills and passing that trait onto their children is like how populations evolve new adaptations.

iii) An engineer designing a more streamlined body is similar to that of a mutation randomly occurring in the genome.

iv) A team changing their car design to match that of their rival is like convergent evolution in unrelated species.

A. i, ii, iii
B. i, iv
C. ii, iv
D. iii, iv

Problem proposed by Josephine Ankomah

Question 25 – Photoreceptors

During a night race in Singapore, artificial lighting is extremely intense. Local trees show disrupted flowering cycles. Which photoreceptor in plants is most likely affected?

A. Phytochrome
B. Cryptochrome
C. Rhodopsin
D. Carotenoids

Problem proposed by Kotryna Mieldažytė

Question 26 – Processing of Light

During a night race, such as that of the Formula 1 Singapore Grand Prix, constant intense visual input occurs. Choose the BEST answer with regards to how light is processed and integrated:

A. Constant exposure to red light at night leads to macular degeneration.
B. Cones are the photoreceptors used for dim vision and have more acuity than rods.
C. Visual information passes through the ventral tagmental area in the thalamus to be distributed to the primary motor cortex.
D. The axons of the ganglion cells in the retina combine to form the optic nerve that carries information to the primary visual cortex.

Problem proposed by Josephine Ankomah

Question 27 – Dehydration

Drivers often suffer mild dehydration. Which hormone directly increases water reabsorption in kidneys?

A. Aldosterone
B. ADH
C. Calcitonin
D. Erythropoietin

Problem proposed by Kotryna Mieldažytė

Question 28 – Blocked Stomata

Plants living near F1 tracks, such as that of the Suzuka circuit, are constantly getting dust, dirt, and debris buildup on their leaves, blocking their stomata. Which of the following will NOT subsequently result from blocked stomata?

A. Buildup of NADH and ATP but stalled rates of sugar production.
B. Reduced rates of photolysis, halting electron transport chain and oxygen production.
C. Elevated leaf temperature, due to high absorption of solar radiation.
D. Increased rates of photoprotection as the dust creates a filamentous layer, protecting leaves from direct sunlight.

Problem proposed by Josephine Ankomah

Question 29 – Pooling of Blood

During acceleration, blood pools in a driver’s legs. Which vessel type prevents backflow?

A. Arterioles
B. Capillaries
C. Veins
D. Lymphatic ducts

Problem proposed by Kotryna Mieldažytė

Question 30 – Tire Wear Particles

Formula 1, although entertaining, severely impacts the health of nearby and even distant ecosystems. F1 tires shed small microplastics called tire wear particles (TWPs), especially during a rough curve or acceleration. These particles are constantly washed and blown away into soil and waterways. Which of the following is a CORRECT outcome of such contamination:

A. Algal bloom in nearby waterbody due to the high nitrogen content in TWPs
B. Increased levels of bioaugmentation to counteract such pollution.
C. Increased elasticity and levels of chitin in fungi and insect exoskeleton as rubber has similar properties.
D. Reduction in overall plant health and ecosystem health due to a change in pH, interfering with soil microbes and enzymes, like sucrase which support carbon cycling.

Problem proposed by Josephine Ankomah