A Journey to Europa 🚀

IJSO MCQ mock test

Solutions

Question Number	Option					Question Number	Option			
1	A	B	~~C~~	D		16	~~A~~	B	C	D
2	A	~~B~~	C	D		17	~~A~~	B	C	D
3	~~A~~	B	C	D		18	A	B	~~C~~	D
4	A	~~B~~	C	D		19	A	B	~~C~~	D
5	A	~~B~~	C	D		20	A	~~B~~	C	D
6	A	~~B~~	C	D		21	A	~~B~~	C	D
7	A	B	C	~~D~~		22	A	B	C	~~D~~
8	A	B	~~C~~	D		23	A	B	~~C~~	D
9	A	~~B~~	C	D		24	A	B	~~C~~	D
10	A	B	C	~~D~~		25	~~A~~	B	C	D
11	A	~~B~~	C	D		26	A	B	C	~~D~~
12	A	B	~~C~~	D		27	A	B	C	~~D~~
13	A	B	C	~~D~~		28	A	B	~~C~~	D
14	A	B	~~C~~	D		29	A	~~B~~	C	D
15	~~A~~	B	C	D		30	A	B	C	~~D~~

Question 01 – Anatomical Marvels from an Unseen Realm

This deep-sea organism's microtubule system, with silica tubules and metalloenzymes interacting with metal-rich vent fluids, points to a chemosynthetic function. Metalloenzymes are key for processing chemicals. Therefore, its primary role is to uptake and enzymatically process dissolved metal ions or reduced gases from vent fluids for energy or biosynthesis, essential for survival in this environment.

So, the correct answer is option **C**.

Question 02 – Foundational Habitability

Europa's stable liquid ocean relies on one key water property. Unlike most substances, ice is less dense than liquid water. This unique characteristic, due to its hexagonal crystalline lattice, means ice floats. On Europa, this allows an insulating ice shell to form on top, trapping heat from tidal forces below and preventing the entire ocean from freezing solid.

So, the correct answer is option **B.**

Question 03 – Plumes of biological evidence

Finding amino acids on Europa isn't enough. The strongest evidence for life would be a significant preference for one chiral form (e.g., L-amino acids) over the other. Terrestrial life almost exclusively uses L-amino acids, making this a strong biosignature.

So, the correct answer is option **A.**

Question 04 – Energy in the Dark Depths

Chemosynthesis directly uses the chemical energy available from the reduced compounds in the vent fluids and oxidants in the ocean. And the presence of potent chemicals supports this conclusion while the other options are not feasible.

Hence, the most suitable answer is **B.**

Question 05 – Rover on the loose

First, we need to find the gravity in Europa using the given information. If 20 full oscillations take 154.98 seconds, then 1 oscillation takes 7.749 seconds.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Rearranging the equation,

$$g = 4\pi^2\frac{l}{T^2}$$

Substituting into the above equation,

$$g = 1.315\ \mathrm{m \cdot s^{-2}}$$

Now that we know the value of gravitational acceleration on Europa's surface, we can find the deceleration of the rover.

$$a = \frac{F}{m} = -\frac{\mu_k mg}{m} = -\mu_k g = 0.03945\ \mathrm{m \cdot s^{-2}}$$

Applying this to basic kinematic equations,

$$v^2 = u^2 + 2as$$

$$s = \frac{v^2 - u^2}{2a} = \frac{0 - 4.5^2}{2 \times -0.03945} = 256.7\mathrm{m}$$

So, the correct answer is option **B.**

Question 06 – Temperature of Cebalrai

The difference between the absolute magnitudes is

$$(M_{\odot} - M) = 4.83 - 2.76 = 2.07$$

Using the definition

$$2.07 = -2.5\log(kL_{\odot}) - (-2.5\log(kL))$$

Using Log properties and the Stefan-Boltzmann equation this expression can also be written as

$2.07 = -2.5\log\frac{R_{\odot}^2 T_{\odot}^4}{R^2 T^4}$ (All constants cancel out!)

Using $R = 12.42R_{\odot}$ and rearranging

$$\frac{T_{\odot}}{T} = 2.188 \Longrightarrow T = 2605\ \mathrm{K}$$

So, the correct answer is option **B**.

Question 07 – Identifying a mysterious gas

A sharply pungent smell, like a swimming pool, indicates chlorine gas. The yellowish color also confirms the fact that the gas is chlorine.

When the moist litmus paper is introduced into the chamber, chlorine reacts with water, producing hydrochloric and hypochlorous acids. The hydrochloric acid is the one that turns litmus paper red, while the hypochlorous acid reacts (slower) with the litmus, turning it white (hypochlorous acid and hypochlorites are well-known bleaching agents).

So, the correct answer is **D**.

Question 08 – Drilling through the Icy Crust

The drill will have to melt a volume of (0.5×15000) = 7500 m^3, multiplying by the density, this is equivalent to 6.9 x 10^5 kg of ice, the energy required to melt a certain number of kilograms of ice can be obtained through its specific heat and latent heat of fusion

$$Q = mcT + mL = m(CT + L) = 4.60 \times 10^6 \text{ MJ}$$

The drill has a power of 2.5 MW, but it has an efficiency of 80%, so its effective power is 2.5×0.8 = 2 MW, therefore, the time it takes to drill the hole is

$$t = \frac{4.60 \times 10^6 \text{MJ}}{2\text{MW}} = 26.6 \text{ days}$$

So, the correct answer is option **C**.

Question 09 – Drilling through the Icy Crust (continued)

The energy required to melt through the ice was already calculated on the previous question (4.60×10^{12} J), the power can be obtained through the energy of the photon expression.

$$E_\gamma = \frac{hc}{\lambda} = 3.61 \times 10^{-19} J$$

$$\mathrm{P} = \mathrm{f} \times \mathrm{E}_\gamma = 7.5 \times 10^{24}\ \mathrm{photons/second} \times 3.61 \times 10^{-19}\ \mathrm{J/photon} = 2.71\ \mathrm{MW}$$

Therefore, the time it takes to melt through the hole is:

$$\mathrm{t} = \frac{4.60\times10^{12}\mathrm{J}}{2.71\mathrm{MW}} = 1.70 \times 10^{6}\ \mathrm{s} = 19.6\ \mathrm{days}$$

So, the correct answer is option **B.**

Question 10 – Signatures of life found in Europa

The most compelling evidence would be: High-resolution imaging confirms a distinct, continuous boundary layer (~8-10 nm thick), enclosing internal contents chemically distinct from the external brine. This describes a cell membrane, a fundamental characteristic of all known life, separating and regulating the internal environment of a cell from its surroundings. The other options describe non-biological features (uniform size/crystalline texture, mineral composition, passive aggregation without compartmentalization).

So, the most suitable option is **D**.

Question 11 – Depth of the Ocean Layer

The time it takes for the laser pulse to travel down the 15 km ice crust plus the ocean layer is half the time of the round trip (152.0/2 = 76.00 microseconds), the time of the trip through the ice crust can be obtained through its velocity:

$n = \frac{c}{v} \Longrightarrow v_{ice} = \frac{c}{n_{ice}} = \frac{3\times10^5 km/s}{1.31} = 2.29 \times 10^5 \frac{km}{s}$, now, calculating the time:

$\Delta t = \frac{d}{v} = \frac{15km}{2.29\times10^5\frac{km}{s}} = 65.5\ \mu s.$

So, out of those 76 microseconds ($\Delta t = 76 - 65.5 = 10.5\mu s$) were travelled down the ocean layer, therefore the depth of the ocean layer is:

$d[km] = v \times t = \frac{c}{n_{water}} \times t = 2.27km$

So, the correct answer is option **B**.

Question 12 – Current in the Ocean

- The magnetic flux through the loop is increasing (because the satellite is approaching with a magnetic field pointing downward).
- Lenz's Law tells us the induced current will act to oppose the increase in flux.
- To oppose a downward field increasing, the loop must create an upward field, which requires a counterclockwise current (by the right-hand rule).
- No electric field accelerates the satellite (so D is incorrect), and A/B both misunderstand Lenz's opposition principle.

So, the correct answer is option **C**.

Question 13 – Genetic Diversity in a Vast Ocean

When considering the vast, potentially isolated "vent islands" and limited ocean circulation, genetic drift would powerfully drive genetic differentiation. In small, isolated populations, random fluctuations in allele frequencies lead to divergence over time, resulting in distinct genetic profiles between geographically separated vent communities.

So, option **D** is the most suitable.

Question 14 – Power for Instruments in Europa

Calculating the reduction potential for the zinc half-cell:

$$E_{Zn} = E^{\circ}_{Zn} - \frac{RT}{zF}\ln\left(\frac{1}{[Zn^{2+}]}\right),\ z = 2, T = 223\ K$$

$$E_{Zn} = -0.76 - \frac{RT}{2F}\ln(\frac{1}{0.100}) = -0.78\ V$$

Doing the same thing for the silver half cell

$$E_{Ag} = E^{\circ}_{Ag} - \frac{RT}{zF}\ln\left(\frac{1}{[Ag^{+}]}\right),\ z = 1, T = 223\ K$$

$$E_{Zn} = 0.80 - \frac{RT}{F}\ln\left(\frac{1}{0.0010}\right) = +0.67\ V$$

The cell potential is given by

$E_{Cell} = E_{Cathode} - E_{Anode}$, where E is the reduction potential, the cathode gets reduced, so it must be the one with the higher potential, in this case it is silver that gets reduced (0.67 > -0.78), therefore

$E_{Cell} = 0.67 - (-0.78) = 1.45\ V$

So, the correct answer is option **C.**

Question 15 – Satellite in Europa

The orbital speed in a circular orbit is given by

$$V = \sqrt{\frac{GM}{r}}$$

Where M is the mass of Europa and r is the distance of the satellite to the center of Europa, (r =1561 km + 550 km = 2111 km), plugging in the values, the speed is close to 1.2 km/s, in order to calculate the time needed for the message to reach earth, you can divide the distance of Europa to Earth by the speed of light c, giving a value close to 35 minutes

So, the correct answer is option **A**.

Question 16 – More about the Satellite

Let T be the period of Europa (and of the satellite). The angular velocity of the satellite can be written as $\omega = \frac{2\pi}{T}$. Let R be the radius of the satellite's orbit. The centripetal acceleration it experiences is $a_{cp} = \omega^2 R = \frac{4\pi^2}{T^2} R$.

$ma_{cp} = \frac{GMm}{R^2} \Longrightarrow \frac{4\pi^2}{T^2} R = \frac{GM}{R^2}$, from which we get the radius $R = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$

Converting everything to SI units and substituting, we get $R = 1.95 \cdot 10^7 \text{m}$

$r = \frac{D}{2} = 500\text{m}$ is the radius of the satellite. In the two cases, the object is at distances $(R + r)$ and $(R - r)$ from the center of Europa respectively.

$$\Delta F = \frac{GMm}{(R-r)^2} - \frac{GMm}{(R+r)^2} = GMm\left(\frac{1}{(R-r)^2} - \frac{1}{(R+r)^2}\right) = GMm \cdot \frac{(R+r)^2-(R-r)^2}{((R+r)(R-r))^2}$$

Calculating, we get $\Delta F = GMm \cdot \frac{4Rr}{(R^2-r^2)^2}$

But $r \ll R$, so the denominator can be approximated to R^4. We get:

$$\Delta F \cong \frac{4GMmr}{R^3} = 8.6 \cdot 10^{-7}\text{N}$$

So, the correct answer is **A**.

Question 17 – The Satellite Receives a Message

The explanation for what happened is the Doppler effect, the frequency of the wave you see depends on the speed of the source relative to you, the equation that relates the frequency as seen by the source f_0 with the frequency you see f is given by:

$$f = f_0 \cdot \frac{\mathrm{c}}{\mathrm{c} + \mathrm{V_r}}$$

where V_r is the radial speed of the source relative to the observer (positive if moving away and negative if moving towards) and c is the speed of the wave, which in this case is the light, algebraically manipulating the expression:

$\mathrm{V_r} = \mathrm{c}\left(\frac{f_0}{f} - 1\right)$

Therefore, $\mathrm{V_r} = 13.79\ \mathrm{km/s}$

So, the correct answer is option **A**.

Question 18 – Travelling around Europa

The limiting case occurs when the speed is equal to the orbital speed

$$v = \left(\frac{GM}{R}\right)^{\frac{1}{2}} = 1.432\,\frac{km}{s}$$

for speeds higher than that, you would end up orbiting Europa instead of being pulled to its surface. The total distance is given by a circumference of a radius r that depends on the latitude ϕ and on the radius R of Europa. Through trigonometry, it is possible to see that $\cos\phi = r/R$ (On the equator the radius is just the radius of Europa since cos(0) = 1, but as you get further from the equator and closer to the poles, the radius decreases, getting closer to 0 since cos 90 = 0), therefore,

$$t_{min} = \frac{2\pi R\cos\phi}{v} = 1h53min$$

So, the correct answer is option **C**.

Question 19 - Limits in a Chemically Fueled Ecosystem

The population would exhibit logistic growth. Initial growth would be rapid as microbes colonize the new energy source. However, as the population increases, the availability of the geothermally produced chemical reductants (the primary energy source) from the vent would become limiting. The maximum sustainable population size would then be dictated by the rate at which the vent continuously supplies these usable chemical energy compounds.

So, the correct answer is **C**.

Question 20 – Jicu takes a walk

Applying the combined gas law:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Rearranging, we get $V_2 = \frac{P_1}{P_2} \cdot \frac{T_2}{T_1} V_1$.

Substituting in the above equation, $V_2 = 250\text{L}$

Since Jicu uses 3L of air a minute, he will last $\frac{250\text{ L}}{3\text{ L/min}} = 83.3\text{ min}$

So, the correct answer is **B**.

Question 21 – The Consequences of the Walk

The distance Jicu travelled = $\frac{83.3 \text{ min}}{60 \text{ min/h}} \times 3 \frac{\text{km}}{\text{h}} = 4.165 \text{ km}$

The total distance the rover will travel is twice that because the rover has to reach Jicu's location and come back to the base. So, the total distance the rover travels is 8.33km.

Total amount of hydrogen used = $0.0040\ g/m \times 8330\ m\ =\ 33.32\ g$

No. of hydrogen moles = $\frac{\text{mass}}{\text{molar mass}} = \frac{33.32 \text{ g}}{2 \text{ g/mol}} = 16.66$ mol

$$2H_2 + O_2 \longrightarrow 2H_2O$$

This shows that the number of water moles is the same as the number of hydrogen moles. So, the number of water moles is 16.66 moles.

PV = nRT

Rearranging the above equation, we get

$V\ =\ \frac{nRT}{P}$

Substituting values to the above equation, we get

V = 341.8 L

So, the correct answer is option **B**.

Question 22 – Biomass Production Estimate

1. Identify the Limiting Reactant:
   The reaction is $2H_2S + O_2 \rightarrow 2S + 2H_2O$. This means 2 moles of H_2S react with 1 mole of O_2.
   - Given H_2S flux = 500 moles/year
   - Given O_2 flux = 200 moles/year to react all 200 moles of O_2, 400 moles of H_2S are needed (200×2=400). Since 500 moles of H_2S are available, H_2S is in excess. Therefore, O_2 is the limiting reactant.
2. Calculate Total Energy Released:
   The reaction yields ΔH≈−420 kJ per mole of O_2.
   Total energy released per year = 200 moles O_2/year×420 kJ/mole O_2= 84000 kJ/year.
3. Calculate Captured Energy:
   The community captures energy with 20% efficiency.
   Captured energy per year = 84000 kJ/year×0.20=16800 kJ/year.
4. Calculate Grams of Carbon Fixed:
   40 kJ of captured energy is required per gram of Carbon fixed.
   Grams of Carbon fixed per year = 16800 kJ/year/40 kJ/gram C=420 grams C/year.
5. Calculate Total Dry Biomass Production:
   Dry biomass is ~50% Carbon.
   Total dry biomass per year = 420 grams C/year/0.50=840 grams dry biomass/year.
   Convert to kilograms: 840 grams/1000 grams/kg=0.84 kg dry biomass/year.

So, the correct answer is option **D.**

Question 23 – Europa Simulation Lab

First, let's find the activation energy of this reaction.

Rearranging the Arrhenius equation, we obtain

$$E_a = -\frac{R \ln \frac{k_2}{k_1}}{\frac{1}{T_2} - \frac{1}{T_1}}$$

Substituting into this equation, we obtain $E_a = 32530\, J/mol$

Now, let's apply the Arrhenius equation once more using the activation energy to find the rate constant for the third temperature.

$$\ln \frac{k_3}{k_1} = -\frac{E_a}{R}\left(\frac{1}{T_3} - \frac{1}{T_1}\right)$$

Substituting values into the equation, we get

$$k_3 = 3.61 \times 10^{-5} s^{-1}$$

So, the correct answer is option **C**.

Question 24 – Europa Simulation Lab (Continued)

This problem can be solved very easily by a simple substitution.

$$[A] = [A]_0 e^{-kt}$$

Rearranging the above equation,

$$\frac{[A]}{[A]_0} = e^{-kt}$$

$$-\frac{1}{k}\ln\frac{[A]}{[A]_0} = t$$

Substituting values,

t = 38401 s = 640 min

So, the correct answer is option **C**.

Question 25 – Selection Pressures

The environment's fluctuating conditions (stable periods vs. shock pulses) mean different traits are advantageous at different times. This leads to disruptive or fluctuating selection, favoring microbes highly specialized for either robustness (during shocks) or rapid metabolic rate (during nutrient pulses), rather than a single intermediate or extreme trait.

So, the correct answer is option **A**.

Question 26 – More Experiments in the Simulation Lab

First, we need to find the number of magnesium moles

No. of Mg Moles = $\frac{\text{mass}}{\text{molar mass}} = \frac{1.20\ g}{24.31\ g/mol}$ = 0.0494 moles

Now, we need to find the amount of heat energy released in the reaction

Change in Heat Energy = $mcT = 0.1\ kg \times 4200\ J/kg.K \times (298 - 273)K = 1050\ J$

Since, only 80% of the total energy from the reaction is used to heat the solution, we should find the total energy released from the reaction.

Total energy released from the reaction = $10500\ J \times \frac{100}{80} = 13125J$

Finally, we can find the molar enthalpy change of the reaction.

Molar Enthalpy change = $\frac{Energy\ Released}{Moles\ Reacted} = \frac{13125\ J}{0.0494\ moles}$ = 264.4 kJ/mol

So, the correct answer is option **D**.

Question 27 – Biological Challenges of Life on Europa

The most critical challenge is Producing the full spectrum of essential amino acids, fatty acids, vitamins, and minerals required for human health using a limited suite of rapidly growing organisms. While other factors are important, ensuring complete human nutrition from a restricted, rapidly growing biomass source is a complex biochemical and biological hurdle for long-term health in isolation.

So, the correct answer is option **D**.

Question 28 – Life in Europa

A. Ozone does indeed have intermediate bonds (bond order is 1.5 – between a single and a double bond). However, the central O atom is sp^2 hybridized, giving ozone a bent structure, not a linear one

B. Ozone is a powerful oxidizer, but the process of turning iodine into iodide is a reduction process, which does not happen under the influence of ozone

C. Passing an electric arc through a dioxygen atmosphere, some of the molecules split into individual atoms enabling ozone-producing reactions to take place

D. Ozone is an oxidizing agent, not a reducing agent, so it can't reduce Fe (III) to Fe (II)

So, the correct answer is **C**.

Question 29 – Age of Europa

The net loss of mass is 238 - 206 = 32u, since an alpha particle has a mass of 4u and beta particles have a mass much smaller than alpha particles, the total number of alpha particles emitted are 32/4 = 8, for every Beta particle emitted, the number of protons increases by 1, 16 protons were lost due to alpha particles, so 6 beta decays would be needed to have a net loss of 10 protons (number of protons goes from 92 to 82).

So, the correct answer is option **B**.

Question 30 – Age of Europa (continued)

$$\frac{N}{N_0} = e^{-\lambda t}$$

1.2% of U-235 remains. This means the ratio $\frac{N}{N_0} = 0.012$.

$$\lambda = \ln 2 / T_{(1/2)} = \ln 2 / (0.704 \text{billionyears}) = 0.9846\ (\text{billionyears})^{-1}$$

Substituting into the first equation, we get

t = 4.49 billion years

So, the correct answer is option **D**.