

DATE : 17/01/2021



Question Paper Code:

51

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Medical | IIT-JEE | Foundations

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Time : 60 Minutes

Answers & Solutions

Max. Marks : 120

for

Indian Olympiad Qualifier in Junior Science 2020-21 (IOQJS) Part-I

Important Instructions :

1. Use of mobile phones, smart watches, and iPad during examination is **STRICTLY PROHIBITED**.
2. In addition to this question paper, you are given OMR Answer Sheet along with candidate's copy.
3. On the OMR Sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles. **Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.**
4. On the OMR Answer Sheet, use only **BLUE or BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. All questions are compulsory.
6. There are 32 questions. All the questions are objective type.
7. The question paper consists of two parts.
 - (a) **Part A1:** This section contains **TWENTY FOUR** multiple choice questions (Q. No. 1 to 24). Each question has four alternatives, out of which **ONLY ONE** is correct.
Each correct answer carries **3 marks** whereas 1 mark will be deducted for each wrong answer.
 - (b) **Part A2:** This section contains **EIGHT** multiple choice questions (Q. No. 25 to 32). Each question has four alternatives, out of which any number of alternatives may be correct. (**MORE THAN ONE CORRECT OPTIONS**).
Each correct answer carries **6 marks** if all the correct alternatives are marked and no incorrect. No negative marks in this part.
8. Rough work should be done only in the space provided.
9. Use of **non-programmable** scientific calculator is allowed.
10. After submitting answer paper, take away the question paper & candidate's copy of OMR for your reference.

INDIAN OLYMPIAD QUALIFIER IN JUNIOR SCIENCE (IOQJS)

PART : A1

OUT OF FOUR OPTIONS, ONLY ONE IS CORRECT. BUBBLE THE CORRECT OPTION.

1. Gravitational collapse is the contraction of an astronomical object under its own gravity. This draws the matter inwards towards the centre of gravity. A neutron star is an example of the collapsed core of a giant star. A certain neutron star of radius 10 km is of mass $1.5 M_{\odot}$. The acceleration due to gravity on the surface of the neutron star is nearly
- (a) $2.0 \times 10^8 \text{ m/s}^2$ (b) $2.0 \times 10^{12} \text{ m/s}^2$
(c) $2.6 \times 10^{16} \text{ m/s}^2$ (d) $2.6 \times 10^{20} \text{ m/s}^2$

Answer (b)

Sol. $M = 1.5 M_{\odot}$
 $= 1.5 \times 2 \times 10^{30} \text{ kg}$
 $R = 10 \text{ km} = 10^4 \text{ m}$

$$g = \frac{GM}{R^2}$$

$$= \frac{6.67 \times 10^{-11} \times 1.5 \times 2 \times 10^{30}}{(10^4)^2}$$

$$= 2.001 \times 10^{12} \text{ m/s}^2$$

$$\approx 2 \times 10^{12} \text{ m/s}^2$$

2. The tympanic membrane (ear drum) is a very delicate component of the human ear. Typically, its diameter is 1 cm. The maximum force the ear can withstand is 2.5 N. In case a diver has to enter sea water of density $1.05 \times 10^3 \text{ kg/m}^3$ without any protective gear, the maximum safe depth for the diver to go into water is about
- (a) 12 m (b) 9 m
(c) 3 m (d) 1.5 m

Answer (c)

Sol. $P = \frac{F}{A}$

$$\rho gh = \frac{F}{\pi R^2}$$

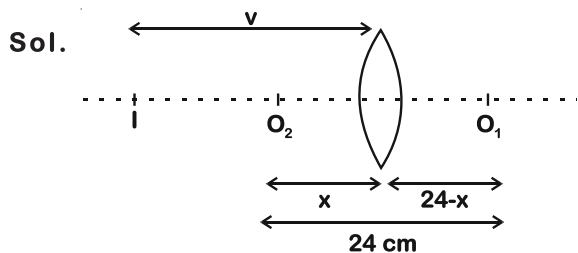
$$1.05 \times 10^3 \times 10 \times h = \frac{2.5}{3.14 \times \left(\frac{1}{2} \times 10^{-2}\right)^2}$$

$$\Rightarrow h = 3.033 \text{ m}$$

$$\approx 3 \text{ m}$$

3. Two illuminated point objects O_1 and O_2 are placed at a distance 24 cm from each other along the principal axis of a thin convex lens of focal length 9 cm such that images of both the objects are formed at the same position. Then the respective distances of the lens from O_1 and O_2 (in cm) are
- (a) 12 and 12 (b) 18 and 6
(c) 14 and 10 (d) 16 and 8

Answer (b)



For object O_1

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{9} = \frac{1}{v} + \frac{1}{24-x} \quad \dots(i)$$

For object O_2

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{9} = -\frac{1}{v} + \frac{1}{x} \quad \dots(ii)$$

Add equation (i) & (ii)

$$\frac{2}{9} = \frac{1}{x} + \frac{1}{24-x}$$

$$\Rightarrow x^2 - 24x + 108 = 0$$

$$\Rightarrow x = 18 \text{ or } 6$$

Distance of O_1 from lens = 18 cm

Distance of O_2 from lens = 24 - x

$$= 24 - 18$$

$$= 6 \text{ cm}$$

4. A nuclear reactor is working at 30% efficiency (i.e. conversion of nuclear energy to electrical energy).

In this reactor ${}_{92}^{235}\text{U}$ nucleus undergoes fission and releases 200 MeV energy per atom. If 1000 kW of electrical power is obtained in this reactor, then the number of atoms disintegrated (undergone fission) per second in the reactor is

- (a) 1.04×10^{17}
 (b) 6.5×10^{12}
 (c) 3.125×10^{12}
 (d) 3.25×10^{32}

Answer (a)

Sol. Efficiency = $\frac{P_o}{P_i} \times 100$

$$\Rightarrow 30 = \frac{1000 \times 10^3 \times 100}{P_i}$$

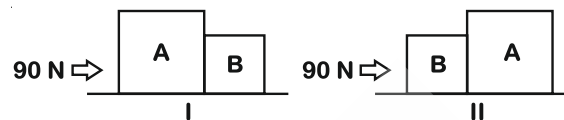
$$\Rightarrow P_i = \frac{10^7}{3} \text{ W}$$

$$\text{Total energy released per second from fuel} = \frac{10^7}{3} \text{ J}$$

$$\begin{aligned} \text{Energy released by one } {}^{235}_{92}\text{U atom} &= 200 \text{ MeV} \\ &= 200 \times 10^6 \times 1.6 \times 10^{-19} \text{ J} \\ &= 3.2 \times 10^{-11} \text{ J} \end{aligned}$$

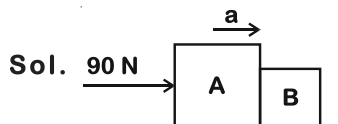
$$\begin{aligned} \text{Number of atoms disintegrated per second in reactor} &= \frac{10^7}{3 \times 3.2 \times 10^{-11}} \\ &= 1.04 \times 10^{17} \end{aligned}$$

5. Two blocks A and B are in contact with each other and are placed on a frictionless horizontal surface. A force of 90 N is applied horizontally on block A (situation I) and the same force is applied horizontally on block B (situation II). Mass of A is 20 kg and B is 10 kg. Then the correct statement is



- (a) Since both the blocks are in contact, magnitude of force by block A on B will be 90 N (situation I) and magnitude of force by block B on A will also be 90 N (situation II)
- (b) Magnitude of force by block A on B is 30 N (situation I) and magnitude of force by block B on A is 60 N (situation II)
- (c) Magnitude of force by block A on B is 60 N (situation I) and magnitude of force by block B on A is 30 N (situation II)
- (d) The 90 N force will produce acceleration of different magnitudes in A and B

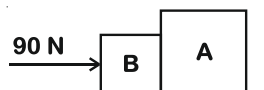
Answer (b)



$$a = \frac{F_{\text{net}}}{(m_A + m_B)}$$

$$\begin{aligned} &= \frac{90}{20 + 10} \\ &= 3 \text{ m/s}^2 \end{aligned}$$

$$\begin{aligned} N_1 &= m_B a \\ &= 10 \times 3 \\ &= 30 \text{ N} \end{aligned}$$

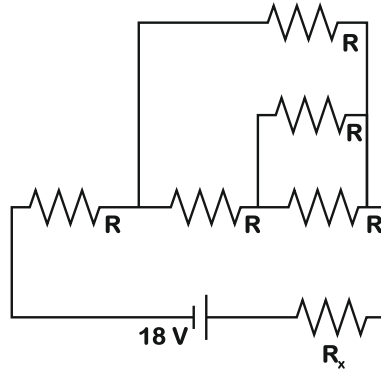


$$a = \frac{F_{\text{net}}}{(m_B + m_A)}$$

$$\begin{aligned} &= \frac{90}{10 + 20} \\ &= 3 \text{ m/s}^2 \end{aligned}$$

$$\begin{aligned} N_2 &= m_A a \\ &= 20 \times 3 \\ &= 60 \text{ N} \end{aligned}$$

6. In the adjoining circuit, $R = 5 \Omega$. It is desired that the voltage across R_x should be 6 V, then the value of R_x should be



(a) 4Ω

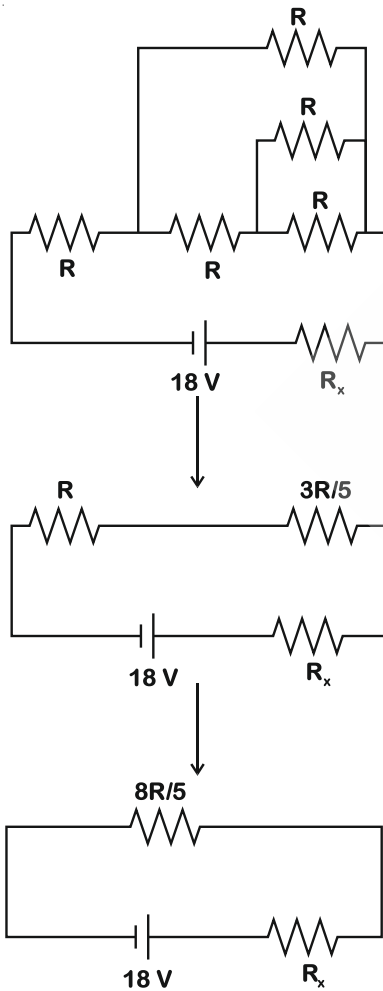
(b) 12Ω

(c) 16Ω

(d) 20Ω

Answer (a)

Sol.



$$\begin{aligned} \text{Potential difference across } \frac{8R}{5} &= 18 - 6 \\ &= 12 \text{ V} \end{aligned}$$

$$\text{Apply Ohm's law across } \frac{8R}{5},$$

$$\Rightarrow V = iR$$

$$\Rightarrow 12 = i \frac{8R}{5}$$

$$\Rightarrow 12 = i \frac{8 \times 5}{5} \quad [\because R = 5 \Omega]$$

$$\Rightarrow i = 1.5 \text{ A}$$

Apply Ohm's law across R_x

$$V = iR_x$$

$$6 = 1.5 \times R_x$$

$$\Rightarrow R_x = 4 \Omega$$

7. In one process for waterproofing, a fabric is exposed to $(\text{CH}_3)_2\text{SiCl}_2$ vapors. The vapors react with the hydroxyl groups on the surface of the fabric or with traces of water to form the waterproofing film $[(\text{CH}_3)_2\text{SiO}]_n$, by the reaction; $n(\text{CH}_3)_2\text{SiCl}_2 + 2n\text{OH}^- \rightarrow 2n\text{Cl}^- + n\text{H}_2\text{O} + [(\text{CH}_3)_2\text{SiO}]_n$ where n stands for a larger integer. The waterproofing film is deposited on the fabric layer upon layer. Each layer is 6 \AA thick [the thickness of the $(\text{CH}_3)_2\text{SiO}$ group]. How much $(\text{CH}_3)_2\text{SiCl}_2$ is needed to waterproof one side of a piece of fabric, 1 m by 2 m, with a film 300 layers thick? The density of the film is 1.0 g/cm^3 .

(a) 0.63 g

(b) 0.36 g

(c) 6.3 g

(d) 3.6 g

Answer (a)

Sol. Length of fabric = 1 m

Width of fabric = 2 m

Thickness of one layer = $6 \text{ \AA} = 6 \times 10^{-10} \text{ m}$

Number of layers = 300

Thickness of film = $300 \times 6 \times 10^{-10}$
 $= 1800 \times 10^{-10} \text{ m}$

Volume of film = $l \times w \times h$

$$= 1 \times 2 \times 1800 \times 10^{-10}$$

$$= 3600 \times 10^{-10} \text{ m}^3$$

$$= 3600 \times 10^{-4} \text{ cm}^3$$

Density of film = 1 g/cm^3

$$\text{Mass of film } [(\text{CH}_3)_2\text{SiO}]_n = d \times V$$

$$= 1 \text{ g/cm}^3 \times 3600 \times 10^{-4} \text{ cm}^3$$

$$= 0.36 \text{ g}$$

As per the reaction,

74 g of $(\text{CH}_3)_2\text{SiO}$ requires 129 g of $(\text{CH}_3)_2\text{SiCl}_2$

$$0.36 \text{ g of } (\text{CH}_3)_2\text{SiO} \text{ requires } = \frac{129}{74} \times 0.36 \text{ g}$$

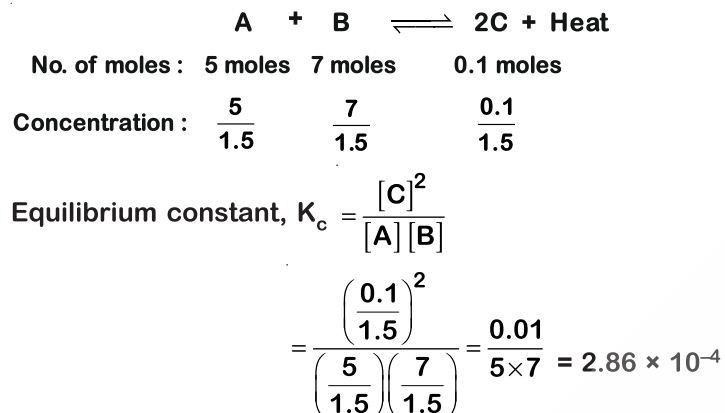
$$= 0.63 \text{ g } (\text{CH}_3)_2\text{SiCl}_2$$

8. Given that at a certain temperature, in 1.5 L vessel, 5.0 mole of A, 7.0 mole of B and 0.1 mole of C are present. Then the value of equilibrium constant for the reaction: $A + B \rightleftharpoons 2C + \text{heat}$ is about
- (a) 7.22×10^{-4} (b) 2.31×10^{-4}
 (c) 7.22×10^{-5} (d) 6.11×10^{-4}

Answer (*)

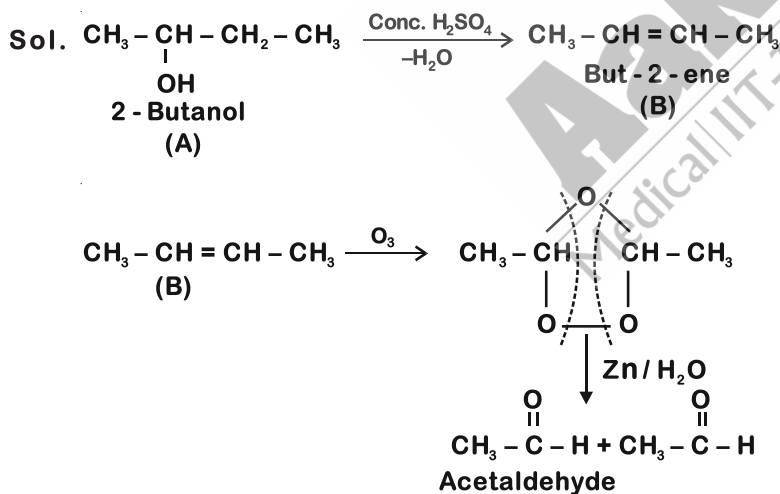
Sol. Given volume of the vessel = 1.5 L

According to the question,



9. An alcohol (A) on dehydration with conc. H_2SO_4 at a high temperature yields compound (B). On ozonolysis every molecule of compound (B) yields two molecules of acetaldehyde. Which of the following is the starting alcohol (A)?
- (a) 1-butanol (b) 2-butanol
 (c) propanal (d) 2-propanol

Answer (b)



10. In an experiment with 100 mL 0.1 M solution of Copper Chloride, by mistake 5 gms of a mixture containing equal weights of Tin, Silver, Lead and Calcium, was added. Finally after some time the solution gets completely decolorized. This is mainly due to :
- (a) Silver reacts with Copper Chloride
 (b) Calcium reacts with Copper Chloride
 (c) All the metals react with Copper Chloride
 (d) Only Lead reacts with Copper Chloride forming white precipitate of lead chloride

Answer (b)

Sol. Calcium reacts with copper chloride

$$\text{Volume of CuCl}_2 = 100 \text{ mL}$$

$$\text{Concentration of CuCl}_2 = 0.1 \text{ M}$$

$$n = \frac{100}{1000} \times 0.1 = 10^{-2} \text{ mol}$$

Constituents of mixture are Sn, Ag, Pb and Ca

$$\text{Mass of mixture (w)} = 5 \text{ g}$$

$$\Rightarrow 4x = 5 \text{ g}$$

$$\Rightarrow x = \frac{5}{4} \text{ g}$$

Where x = Mass of each constituent.

$$\text{Moles of Ca} = \frac{5}{4} \times \frac{1}{40} = 0.031 = 3.1 \times 10^{-2} \text{ mol}$$

Moles of Sn and Pb are very less as compared to moles of Cu and Ca. Moles of Ca are already in excess. Also it is the most reactive.

11. Triclosan ($\text{C}_{12}\text{H}_7\text{Cl}_3\text{O}_2$) is an antibacterial and antifungal agent. It is a polychloro phenoxy phenol. It is widely used as a preservative and antimicrobial agent in personal care products such as soaps, skin creams, and deodorants etc. A label on a 200 mL hand sanitizer bottle claims that it contain Triclosan 0.2% w/v. What will be the number of molecules of Triclosan present in the bottle? (N_A is Avogadro's Number)

(a) $1.4 \times 10^{25} N_A$

(b) $1.4 \times 10^{24} N_A$

(c) $1.4 \times 10^{23} N_A$

(d) $1.4 \times 10^{22} N_A$

Answer (*)

Sol. 0.2% w/V (Given)

\therefore 100 mL of solution contains 0.2 g triclosan

200 mL of solution contains 0.4 g triclosan

$$\begin{aligned} \text{Number of molecules of triclosan} &= \frac{\text{Given mass}}{\text{Mol. mass}} \times N_A \\ &= \frac{0.4}{289.5} \times 6.022 \times 10^{23} \\ &\sim 8.4 \times 10^{20} \end{aligned}$$

12. Suppose that A and B forms compound B_2A_3 and B_2A . If 0.05 mole of B_2A_3 weighs 12 g and 0.1 mole of B_2A weighs 10 g, what are the atomic weight of A and B respectively?

(a) 70 and 25

(b) 50 and 20

(c) 40 and 30

(d) 30 and 40

Answer (*)

Sol. Let atomic weight of A be 'x' u

And atomic weight of B be 'y' u

B_2A_3	B_2A
Mass of 0.05 moles of $\text{B}_2\text{A}_3 = 12 \text{ g}$	Mass of 0.1 moles of $\text{B}_2\text{A} = 10 \text{ g}$
Mass of 1 mole of $\text{B}_2\text{A}_3 = \frac{12}{0.05} = 240 \text{ g}$	Mass of 1 mole of $\text{B}_2\text{A} = \frac{10}{0.1} = 100 \text{ g}$
or, $2y + 3x = 240$(i)	or, $2y + x = 100$(ii)

Now, subtracting equation (ii) from equation (i), we get

$$\begin{array}{r} 2y + 3x = 240 \\ 2y + x = 100 \\ \hline 2x = 140 \end{array}$$

So, $x = 70$

On putting value of 'x' in equation (ii)

$$2y + 70 = 100$$

$$y = 15$$

\therefore Atomic weight of A and B are 70 u and 15 u respectively.

13. If in a wheat mutant, the length of chromosome 1B was found to be $6.7 \mu\text{m}$ instead of $5.0 \mu\text{m}$, approximately how many additional base pairs are incorporated in the mutant chromosome?
- (a) 0.5×10^4 bp (b) 5×10^4 bp
(c) 1.7×10^4 bp (d) 5.78×10^4 bp

Answer (a)

Sol. The length of the mutated chromosome 1B = $6.7 \mu\text{m} = 6.7 \times 10^3$ nm

The original length of the chromosome 1B = $5.0 \mu\text{m} = 5.0 \times 10^3$ nm

The increased length of the chromosome = $(6.7 - 5.0) \mu\text{m} = 1.7 \mu\text{m} = 1.7 \times 10^3$ nm

Since, the distance between two corresponding base pairs = 0.34 nm

$$\begin{aligned} \text{So, the number of additional bases incorporated in the mutated chromosome} &= \frac{1.7 \times 10^3}{0.34} \text{ bp} \\ &= 5 \times 10^3 \text{ bp} \\ &= 0.5 \times 10^4 \text{ base pairs} \end{aligned}$$

14. Considering following characteristics, identify the correct inheritance pattern from the given options.
- Most affected individuals are male.
 - Affected sons result from female parents who are either affected or who are known to be carriers because they have affected brothers, fathers, or maternal uncles.
 - Affected daughters are born to affected fathers and either affected or carrier mothers.
 - The sons of affected mothers should be affected.
 - Approximately half the sons of carrier mothers should be affected.
- (a) Autosomal Recessive Inheritance
(b) Autosomal Dominant Inheritance
(c) Sex-Linked Recessive Inheritance
(d) Sex-Linked Dominant Inheritance

Answer (c)

Sol. The given characteristics are related to sex-linked recessive inheritance pattern. This type of inheritance pattern shows its transmission from normal carrier female to male progeny.

In X-linked recessive inheritance, a mutation in gene on the X-chromosome causes the phenotype to be always expressed in males and in females who carry the affected gene on both X-chromosomes. Females with one copy of the mutated gene are carriers.

Examples of sex-linked recessive disorders are haemophilia and colour-blindness.

15. In a marine ecosystem with rich diversity of fauna, which of the following images would be a correct representation of pyramid of biomass?



Answer (d)

Sol. Pyramid of biomass in a marine ecosystem is always inverted. As the biomass of primary producers (phytoplanktons) is much less than the zooplanktons, which is less than the small fish and the big fish having the maximum biomass.

16. The transpiration pull is maximum under which of the following conditions?

- (a) Closed stomata, low light intensity, humid air
- (b) Open stomata, dry air, moist soil
- (c) Open stomata, dry air, dry soil
- (d) Open stomata, high humidity in air, moist soil

Answer (b)

Sol. The transpiration pull will be maximum when:

The stomata are open, atmosphere is dry and the soil is moist.

Open stomata will help in losing water, since the atmosphere is dry, more water will be released in the atmosphere. Moist soil provides water that does not let the water column break in xylem.

17. *Curcuma longa*, *Azadirachta indica*, Basmati Rice, Indian Ginseng are all related to which of the following concepts?

- (a) Bioterrorism
- (b) Biomagnification
- (c) Biopiracy
- (d) Biodegradation

Answer (c)

Sol. *Curcuma longa* (Turmeric), *Azadirachta indica* (Neem), Basmati rice, Indian Ginseng (Ashwagandha) are the plants which are related to biopiracy.

Biopiracy is unethical commercial exploitation or monopolization of biological or genetic materials, native to a country without any fair compensation to the people or government of that country.

18. Read following criteria carefully.

- Slow evolutionary change relative to similar entities
- Gross similarity to an ancestral fossil
- Very low taxonomic richness today compared to the past
- Phylogenetic inference of specific characters as plesiomorphic
- Phylogenetic inference of genealogical divergence between other groups that diverged in the distant past
- Known in the fossil record before being discovered alive

These criteria can be used to categorize a group of organisms the most probably into

- (a) Connecting links
- (b) Living fossils
- (c) Endangered species
- (d) Extinct species

Answer (b)

Sol. Living fossils bear strong similarity with the species, which had before been identified only through the fossil records. It is the term which is generally applied for formerly undiscovered life forms. They were thought to have been long extinct. They show slow evolutionary change relative to similar entities. They show plesiomorphic character while reconstructing the evolutionary history of related species by grouping them in successively more inclusive sets based on shared ancestry. They are very less in number today as compared to the past.

- Connecting links are the organisms having characteristics of two different groups of organisms.
- Endangered species or threatened species are the organisms that are at the risk of extinction.
- Extinct species are those species which no longer exists on the Earth.

19. If $x^2 + ax + b = 0$ and $x^2 + bx + a = 0$ have one common root, then

- (a) $a + b = 0$ (b) $a + b = 1$
(c) $a + b = -1$ (d) $a^2 + b^2 = 1$

Answer (c)

Sol. Let α be the common root of $x^2 + ax + b = 0$ and $x^2 + bx + a = 0$.

$$\text{i.e., } \alpha^2 + a\alpha + b = 0 \quad \dots(i)$$

$$\text{and, } \alpha^2 + b\alpha + a = 0 \quad \dots(ii)$$

$$\therefore \alpha^2 + a\alpha + b = \alpha^2 + b\alpha + a$$

$$\Rightarrow a\alpha - b\alpha = a - b$$

$$\Rightarrow \alpha(a - b) = (a - b)$$

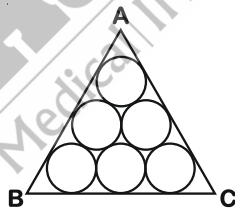
$$\Rightarrow \alpha = 1$$

Put in both the given equations, we get

$$1 + a + b = 0$$

$$\text{or } a + b = -1$$

20. Six circles each of radius 3 cm are inscribed in an equilateral triangle ABC such that they touch each other and also touch the sides of the triangle as shown in the adjacent figure. Then height of triangle ABC is



(a) $6(2\sqrt{3} + 3)$

(b) $3(2\sqrt{3} + 6)$

(c) $3(2\sqrt{3} + 3)$

(d) $6(2 + \sqrt{3})$

Answer (c)

Sol. In ΔPBR , $\angle PBR = 30^\circ$ and $PR = 3$ cm

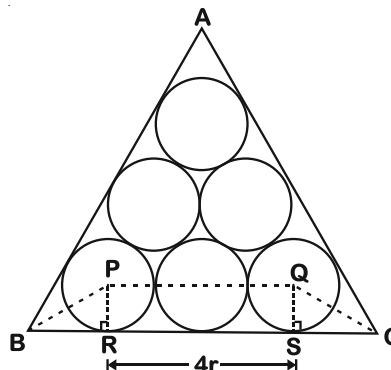
$$\Rightarrow \tan 30^\circ = \frac{PR}{BR}$$

$$\Rightarrow \frac{1}{\sqrt{3}} = \frac{3}{BR}$$

$$BR = 3\sqrt{3} \text{ cm}$$

$$\text{Similarly, } CS = 3\sqrt{3} \text{ cm}$$

$$\text{and, } RS = 4 \times \text{radius of circle}$$



$$RS = 4 \times 3 = 12 \text{ cm}$$

$$\therefore BC = BR + RS + CS$$

$$= 3\sqrt{3} + 12 + 3\sqrt{3} = 6(\sqrt{3} + 2) \text{ cm}$$

$$\text{Now, height of the equilateral } \triangle ABC = \frac{\sqrt{3}}{2} \times \text{side of } \triangle ABC$$

$$= \frac{\sqrt{3}}{2} \times 6(\sqrt{3} + 2)$$

$$= 3\sqrt{3}(\sqrt{3} + 2) \text{ cm or } 3(2\sqrt{3} + 3) \text{ cm}$$

21. Find the remainder when x^{51} is divided by $x^2 - 3x + 2$

(a) x

(b) $(2^{51} - 2)x + 2 - 2^{51}$

(c) $(2^{51} - 1)x + 2 - 2^{51}$

(d) 0

Answer (c)

Sol. Here, $x^2 - 3x + 2 = (x - 1)(x - 2)$

$$\therefore x^{51} = (x - 1)(x - 2) \times Q(x) + (ax + b) \dots(i) \quad [\text{where } Q(x) \text{ and } (ax + b) \text{ are quotient and remainder respectively}]$$

Put $x = 1$ in eq. (i),

$$\Rightarrow 1 = 0 + a + b$$

$$\Rightarrow a + b = 1$$

Put $x = 2$ in eq. (i)

$$2^{51} = 0 + 2a + b$$

$$\Rightarrow 2a + b = 2^{51}$$

On solving eqn. (ii) and (iii), we get

$$a = 2^{51} - 1 \text{ and } b = 2 - 2^{51}$$

$$\therefore \text{Remainder} = (ax + b) = (2^{51} - 1)x + 2 - 2^{51}$$

22. If $\frac{3}{x-2} < 1$, where x is a real number, then

(a) $2 < x < 5$

(b) $x < 2$ or $5 < x$

(c) $x < -2$ or $x > 5$

(d) None of these

Answer (b)

Sol. Given,

$$\frac{3}{x-2} < 1$$

$$\Rightarrow \frac{3}{x-2} - 1 < 0$$

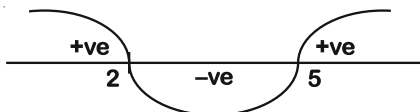
$$\Rightarrow \frac{3-x+2}{x-2} < 0$$

$$\Rightarrow \frac{5-x}{x-2} < 0$$

$$\Rightarrow \frac{x-5}{x-2} > 0$$

By wavy curve method,

Critical points are 2 and 5.



$$[\because \frac{x-5}{x-2} > 0 \text{ for } x > 5]$$

$$\therefore \frac{x-5}{x-2} > 0 \text{ for } x < 2 \text{ or } x > 5$$

23. If $100^{25} - 25$ is written in decimal notations, then the sum of its digits is

- (a) 444 (b) 442
(c) 424 (d) 422

Answer (a)

$$\begin{aligned} \text{Sol. } 100^{25} - 25 &= (10^2)^{25} - 25 \\ &= 10^{50} - 25 \\ &= \underbrace{999 \dots 975}_{48 \text{ times}} \quad [\because 100 - 25 = 75] \end{aligned}$$

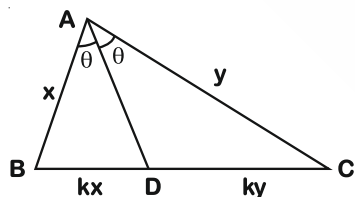
$$\begin{aligned} \therefore \text{Sum of digits} &= (9 \times 48) + 7 + 5 \\ &= 432 + 12 \\ &= 444 \end{aligned}$$

24. ABC is a triangle, the bisector of angle A meets BC in D. The relation between AD, AB and AC is

- (a) $AD > \sqrt{AB \cdot AC}$ (b) $AD > AB \cdot AC$
(c) $AD = \sqrt{AB \cdot AC}$ (d) $AD < \sqrt{AB \cdot AC}$

Answer (d)

Sol.



Let $AB = x$ and $AC = y$

$\Rightarrow BD = kx$ and $CD = ky$ for any positive real number k .

$$\left[\because \frac{AB}{AC} = \frac{BD}{CD} \text{ by interior angle bisector theorem} \right]$$

By applying cosine rule in $\triangle ABD$ and $\triangle ACD$,

$$\begin{aligned} \cos \theta &= \frac{x^2 + AD^2 - (kx)^2}{2x \cdot AD} = \frac{y^2 + AD^2 - (ky)^2}{2y \cdot AD} \\ \Rightarrow y(x^2 + AD^2 - k^2x^2) &= x(y^2 + AD^2 - k^2y^2) \\ \Rightarrow x^2y + yAD^2 - k^2x^2y - xy^2 - xAD^2 + k^2xy^2 &= 0 \\ \Rightarrow (1 - k^2)x^2y - (1 - k^2)xy^2 &= (x - y)AD^2 \\ \Rightarrow xy(1 - k^2)(x - y) &= (x - y)AD^2 \\ \Rightarrow xy(1 - k^2) &= AD^2 \quad [\because (x - y) \text{ is constant}] \end{aligned}$$

$$\Rightarrow AB \times AC (1 - k^2) = AD^2$$

$$\Rightarrow \frac{AD^2}{AB \times AC} = 1 - k^2$$

$$\Rightarrow \frac{AD^2}{AB \times AC} < 1 \quad [\because 1 - k^2 < 1]$$

$$\Rightarrow AD^2 < AB \times AC$$

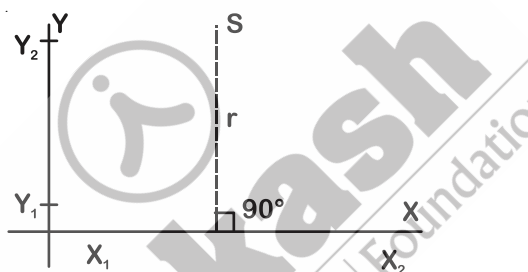
$$\therefore AD < \sqrt{AB \times AC}$$

PART : A2

MORE THAN ONE CORRECT OPTIONS. BUBBLE ALL CORRECT OPTIONS ONLY.

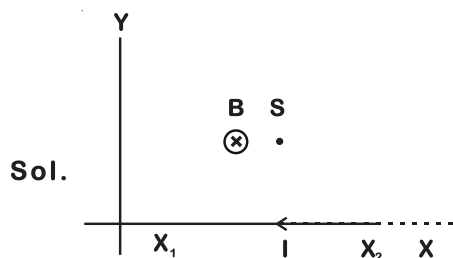
25. An infinitely long conductor when carrying current I , produces a magnetic field B around it. If such a conductor is placed along the X-axis, then the magnitude of B at a distance r is given by the relation

$B = \frac{\mu_0 2I}{4\pi r}$, (where $\frac{\mu_0}{4\pi} = 10^{-7} \text{ NA}^{-2}$ is a constant). The following figure shows such an infinitely long conductor placed along X-axis carrying current I and B at S is $2 \times 10^{-4} \text{ T}$, directed into the plane of the paper at S . Given $r = 1 \text{ cm}$. Then, the correct statements are



- (a) $I = 10 \text{ A}$
- (b) The number of electrons transported across the cross section of the conductor during time 1 s is 6.25×10^{19}
- (c) The direction of current I is from X_2 to X_1
- (d) The electrons will flow in the direction X_2 to X_1

Answer (a, b, c)



$$B = \frac{\mu_0 \times 2I}{4\pi r}$$

$$2 \times 10^{-4} = \frac{10^{-7} \times 2I}{1 \times 10^{-2}}$$

$$\Rightarrow I = 10 \text{ A} \quad [\text{Direction } X_2 \text{ to } X_1]$$

$$q = I \times t$$

$$n \times 1.6 \times 10^{-19} = 10 \times 1 \quad [\because q = ne = n \times 1.6 \times 10^{-19}]$$

$$\Rightarrow n = \frac{10}{1.6 \times 10^{-19}}$$

$$\therefore n = 6.25 \times 10^{19}$$

26. The ratio of the charge of an ion or subatomic particle to its mass (q/m) is called specific charge. Then the correct options are
- SI unit of specific charge can be written as $\text{A}\cdot\text{s}/\text{kg}$.
 - If all the isotopes of hydrogen are ionized then tritium will have least specific charge among them.
 - Specific charge of an α -particle will be greater than that of an electron.
 - Specific charge ratio of an electron is $1.75 \times 10^{11} \text{ C/kg}$.

Answer (a, b, d)

Sol. S.I unit of specific charge = $\frac{\text{A}\cdot\text{s}}{\text{kg}}$

Specific charge of Tritium (H_1^3) = $\frac{e}{3m}$

Specific charge of Protium (H_1^1) = $\frac{e}{m}$

Specific charge of Deuterium (H_1^2) = $\frac{e}{2m}$

Therefore, specific charge of (H_1^3) is smaller than (H_1^1) and (H_1^2)

Specific charge of electron = $\frac{1.6 \times 10^{-19}}{9 \times 10^{-31}} = 0.175 \times 10^{12} \text{ C/kg} = 1.75 \times 10^{11} \text{ C/kg}$

Specific charge of α particle = $\frac{2 \times 1.6 \times 10^{-19}}{4 \times 1.6 \times 10^{-27}} = 5 \times 10^7 \text{ C/kg}$

Therefore, specific charge of electron > specific charge of α particle

27. Acetylene torches and burners used by glassblowers produce intense ultraviolet light. Glassblowers wear special glasses that contain which of the following elements to absorb the UV?
- Neodymium
 - Praseodymium
 - Cerium
 - Didymium

Answer (a, b)

Sol. Neodymium and Praseodymium are the elements which are present in special glasses used by glassblowers.

Note: Didymium is a mixture of Neodymium and Praseodymium

28. Equal lengths of magnesium ribbons are taken in four test tubes A, B, C and D. In test tube A, 1M acetic acid is added; in test tube B, 1M HCl is added; in test tube C, 1M HNO₃ is added; and in test tube D, 1M NaOH is added. The observed results will be:

- (a) The fizzing occurs more vigorously in A (b) The fizzing occurs more vigorously in B
(c) The fizzing occurs more vigorously in C (d) The fizzing occurs more vigorously in D

Answer (b, c)

Sol. Test tube D contains NaOH and Mg does not react with NaOH. Now, out of test tubes A, B and C, test tubes B and C contain strong acids and test tube A contains a weak acid. So fizzing occurs more vigorously in test tubes B and C i.e. with 1M HCl and 1M HNO₃.

29. Choose the correct statements from following options.

- (a) A robust adaptive immune response is initiated using weakened forms of the bacterium known as live attenuated vaccines.
(b) Administration of a killed or chemically inactivated virus can trigger a weaker adaptive immune response, but can be strengthened with booster doses.
(c) A conjugate or multivalent component always reduces immunogenicity of the vaccine.
(d) Inclusion of alum, cytokines, and/or lipids always reduces the immune response to a vaccine.

Answer (a, b)

Sol. • Live attenuated vaccines contain whole bacteria or viruses which have been “weakened” (attenuated) so that they create a protective immune response but do not cause disease in healthy people.

- Administration of killed or chemically inactivated virus can trigger a weaker adaptive immune response but can be strengthened by booster doses because the killed pathogens in a properly produced vaccine do not reproduce, booster shots are required periodically to reinforce the immune response.
- A conjugate or multivalent vaccine increases immunogenicity of the vaccine as they fight a different type of bacteria. These bacteria have antigens with an outer coating of sugar like substances called polysaccharides that is chemically linked to a protein.
- Alum, cytokines, or lipids are the adjuvants which are used in some vaccines that help to create a stronger immune response in people receiving the vaccine.

Hence, option (a) and (b) are correct.

30. The minimum energy required to exist that is the energy required to perform chemical reactions even when a person is at rest is called the *basal metabolic rate* (BMR), which accounts for about 50 to 70 percent of the daily energy expenditure in most sedentary individuals. It is influenced by many factors. Some statements are made about these factors. Choose the correct statements from the following options.

- (a) Thyroid hormone decreases metabolic rate
(b) Growth hormone increases metabolic rate
(c) Fever decreases metabolic rate
(d) Malnutrition decreases metabolic rate

Answer (b, d)

Sol. • Thyroxine secreted from thyroid gland increases the basal metabolic rate.

- Fever is the common pathological cause for high BMR. It is estimated that for every 1 degree fahrenheit rise in body temperature, the BMR increases by 7%.

Hence, option (b) and (d) are correct.

31. If $0 \leq x \leq \pi$ and $81^{\sin^2 x} + 81^{\cos^2 x} = 30$, then $x =$

(a) $\frac{\pi}{6}$

(b) $\frac{\pi}{3}$

(c) $\frac{5\pi}{6}$

(d) $\frac{2\pi}{3}$

[Useful information : $\pi^c = 180^\circ$, $\sin(180 - \theta) = \sin \theta$, $\sin \theta \geq 0$ when $0 \leq \theta \leq 180^\circ$]

Answer (a, b, c, d)

Sol. $81^{\sin^2 x} + 81^{\cos^2 x} = 30$

$$81^{\sin^2 x} + 81^{1-\sin^2 x} = 30 \quad [\because \cos^2 x = 1 - \sin^2 x \text{ for all values of } x]$$

$$\Rightarrow \left(81^{\sin^2 x}\right)^2 + 81 = 30 \times 81^{\sin^2 x}$$

Let $81^{\sin^2 x} = t$

$$\therefore t^2 + 81 = 30t$$

$$\Rightarrow t^2 - 30t + 81 = 0$$

$$\Rightarrow t^2 - 27t - 3t + 81 = 0$$

$$\Rightarrow t(t - 27) - 3(t - 27) = 0$$

$$\Rightarrow (t - 3)(t - 27) = 0$$

$$\Rightarrow t = 3 \text{ or } 27$$

$$\therefore 81^{\sin^2 x} = 3$$

$$\Rightarrow 3^{4\sin^2 x} = 3$$

$$\Rightarrow 4\sin^2 x = 1$$

$$\Rightarrow \sin x = \pm \frac{1}{2}$$

$$\therefore x = \frac{\pi}{6}, \frac{5\pi}{6} \quad [\because 0 \leq x \leq \pi]$$

When, $81^{\sin^2 x} = 27$

$$\Rightarrow 3^{4\sin^2 x} = 3^3$$

$$\Rightarrow \sin^2 x = \frac{3}{4}$$

$$\Rightarrow \sin x = \pm \frac{\sqrt{3}}{2}$$

$$\therefore x = \frac{\pi}{3}, \frac{2\pi}{3} \quad [\because 0 \leq x \leq \pi]$$

32. Given $(a - b)^2 + (a - c)^2 = (b - c)^2$, then which of the following statements are true?

- (a) Equation is valid when $b = c$ and $a \neq c$
- (b) Equation is valid when $a = b$
- (c) Equation is valid when $a = c$
- (d) Given equation is not valid when a, b and c are distinct

Answer (b, c, d)

Sol. $(a - b)^2 + (a - c)^2 = (b - c)^2$

$$\Rightarrow a^2 + b^2 - 2ab + a^2 + c^2 - 2ac = b^2 + c^2 - 2bc$$

$$\Rightarrow 2a^2 - 2ac = 2ab - 2bc$$

$$\Rightarrow 2a(a - c) = 2b(a - c)$$

$$\Rightarrow a(a - c) - b(a - c) = 0$$

$$\Rightarrow (a - c)(a - b) = 0$$

$$\Rightarrow a = c \text{ or } a = b$$

$$\therefore a = b = c$$

□ □ □

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Edition: 2020-21

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