NSEJS 2026

Held On 22 November, Sunday 2026	TIME : 2 : 30 PM to 4 : 30 PM

JUNIOR SCIENCE

PART A-1

Question 1 (Part A-1, single correct, +3 / -1)

A suction cup is attached to the smooth ceiling in a room. The maximum weight that can be supported by the suction cup depends on (I) its area of contact with the ceiling, (II) the air pressure outside the suction cup, (III) height of the room up to the ceiling, (IV) thickness of the roof above the ceiling. The correct options are

(a) I and II (b) I, II and III (c) I, III and IV (d) I and IV

Solution

Correct option: A. **Method:** When the cup is pressed against the ceiling, air is expelled from inside it, so the pressure inside is much less than the atmospheric pressure outside. The maximum force holding the cup is $(P_0 - P_{in}) \times A$, about $P_0 \times A$ when the inside is nearly evacuated. So the maximum weight depends on (I) the area of contact A and (II) the outside air pressure P_0. The height of the room and the thickness of the roof do not affect the pressure difference across the cup.

Answer: (A).

Question 2 (Part A-1, single correct, +3 / -1)

A 100 m sprinter increases her speed uniformly from rest, at a rate of 2.0 ms^{-2} up to 64.0 m and covers the remaining track (distance) with a uniform speed. The correct statement is

(a) The sprinter covers the last half of the track (distance) in 3.35 sec

(b) The average speed of the sprinter during the entire sprint (race) is close to 9.756 ms^{-1}

(c) The slope of the velocity time graph during the last 36 meter of race is 2 (SI unit)

(d) There is no force of friction between sprinter and the ground during the last 30 meters of the race

Solution

Correct option: B. **Method:** Accelerated part (0 to 64 m): $v^2 = 2 \times 2 \times 64 = 256$, so v = 16 ms^{-1} and $t_1 = 16/2 = 8$ s. Uniform part (36 m): $t_2 = 36/16 = 2.25$ s. Total time = 10.25 s, so average speed = 100/10.25 = 9.756 ms^{-1}. The last 50 m takes $(16 - \sqrt{200})/2 + 2.25 = 3.18$ s, not 3.35 s, so (a) is wrong. In the last 36 m the speed is constant, so the slope of the v-t graph is zero, not 2, so (c) is wrong. The sprinter pushes the ground backward, so forward static friction acts, so (d) is wrong.

Answer: (B).

Question 3 (Part A-1, single correct, +3 / -1)

Mechanical engineer Richard James invented a metal slinky in 1943 as an iconic toy consisting of a tightly coiled metal wire (Fig a). Students use it to mimic and to understand the magnetic field produced by a current carrying solenoid. In an experiment, a metal slinky consisting of insulated wires is stretched slightly and a direct current is passed through it (Fig b). The resulting magnetic field causes Figure (a): a metal slinky, a tightly coiled helix. Figure (b): the slinky stretched out as a horizontal solenoid with a battery connected across its ends.

Fig. (a) Metal Slinky



Fig. (b) Slinky as solenoid

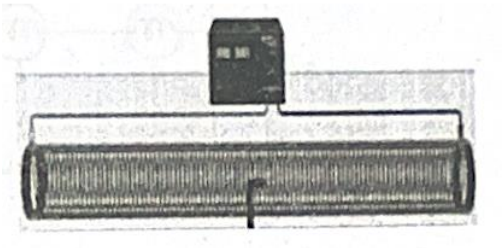


Figure for Question 3 (as printed in the paper).

(a) the slinky to compress in length

(b) the slinky to stretch out further to increase its length

(c) no effect on the length of the slinky

(d) stretching or compressing the slinky depending upon the direction of current passed

Solution

Correct option: A. **Method:** The stretched slinky behaves like a solenoid. In adjacent turns of a solenoid the current flows in the same direction, and two parallel conductors carrying currents in the same direction attract each other. Hence the turns attract one another and the slinky compresses in length. Reversing the current reverses the current in every turn, so adjacent currents are still parallel and still attract; the effect does not depend on the direction of the current.

Answer: (A).

Question 4 (Part A-1, single correct, +3 / -1)

The magnitude of the force of gravitation between two homogeneous identical solid spheres is F_0. If each sphere shrinks to new homogeneous sphere of same mass and 80% diameter and the distance between the centers of the new spheres is doubled then the force of gravitation between the two spheres would be

(a) 0.64 F_0 (b) 0.50 F_0 (c) 0.36 F_0 (d) 0.25 F_0

Solution

Correct option: D. **Method:** For homogeneous spheres the force is the same as if the whole mass were at the centre: $F_0 = Gm^2/r^2$. The mass of each sphere is unchanged and the distance between the centres becomes 2r, so $F = Gm^2/(2r)^2 = F_0/4 = 0.25\ F_0$. The change in diameter does not matter.

Answer: (D).

Question 5 (Part A-1, single correct, +3 / -1)

A concave mirror of focal length f produces a doubly magnified real image of an object placed on the principal axis at distance x from the pole. In terms of the focal length f, the separation between the object and its image, along the principal axis, is

(a) 4.5 f (b) 4.0 f (c) 2.5 f (d) 1.5 f

Solution

Correct option: D. **Method:** Using the New Cartesian sign convention, the focal length is -f and the object distance is u = -x. A real image is inverted, so magnification m = -v/u = -2, giving v = 2u = -2x. The mirror formula gives 1/v + 1/u = 1/f, so -1/(2x) - 1/x = -1/f, giving 3/(2x) = 1/f and x = 1.5f. The image distance is |v| = 2x = 3f, so the separation between object and image is 3f - 1.5f = 1.5f.

Answer: (D).

Question 6 (Part A-1, single correct, +3 / -1)

Two books A and B are made of paper from the same roll. The dimensions of the book B are twice of those of book A. Both the books are kept with their largest flat area on a horizontal table. The correct statement is

(a) The weight of book B is 6 times that of book A
(b) The volume of book B is 6 times that of book A
(c) The pressure exerted by book B on the table is twice to that exerted by book A
(d) The density of book A is less than that of book B

Solution

Correct option: C. **Method:** Let A have dimensions l × b × h. Then B has dimensions 2l × 2b × 2h, so its volume is 8 times that of A, and since both are the same material (same density), its weight is also 8 times. So (a), (b) and (d) are wrong. The area of the largest face of B is (2l)(2b) = 4 times that of A. Pressure is weight over area, so $P_B/P_A = 8/4 = 2$.

Answer: (C).

Question 7 (Part A-1, single correct, +3 / -1)

Three different circuits (1, 2 and 3) are designed using three identical batteries of equal emf E and the resistors of R ohm and 2R ohm with the help of connecting wires of negligible resistance as shown. In the laboratory the current is measured as I_1 between A_1B_1, I_2 between A_2B_2 and I_3 between A_3B_3 such that Figure: three circuits (1), (2) and (3). In each, a battery of emf E is on the left, and a branch A-B with an ammeter in series with a 2R resistor is connected directly across the battery. Circuit (1) has one more branch with two R resistors in series; circuit (2) adds a second 2R branch; circuit (3) adds a third 2R branch.

Fig. (1)

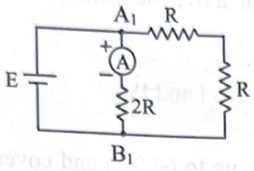


Fig. (2)

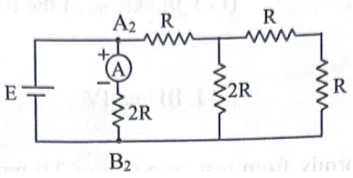


Fig. (3)

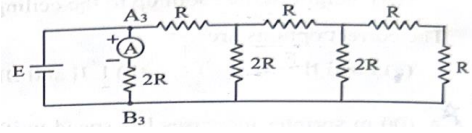


Figure for Question 7 (as printed in the paper).

(a) $I_1 > I_2 > I_3$ (b) $I_1 < I_2 < I_3$ (c) $I_1 = I_2 = I_3$ (d) $I_1 = I_2 + I_3$

Solution

Correct option: C. **Method:** In each circuit, the branch A-B (ammeter in series with 2R) is connected directly between the two terminals of the battery through wires of negligible resistance. The battery is ideal, so the potential difference across every branch connected across it is E. The current through branch AB is I = E/2R in all three circuits. The remaining resistors only form other parallel branches across the same battery; they change the total current drawn from the battery but not the current in branch AB. So $I_1 = I_2 = I_3 = E/2R$.

Answer: (C).

Question 8 (Part A-1, single correct, +3 / -1)

Four identical bulbs A, B, C and D are connected to a supply of E volt as shown in figure. The correct statement is Figure: a battery of E volt at the bottom. Bulb B is connected directly across the supply on the top wire; bulbs C and D are in series on a middle wire, also directly across the supply; bulb A is on the left, with a plain connecting wire joined in parallel with it.

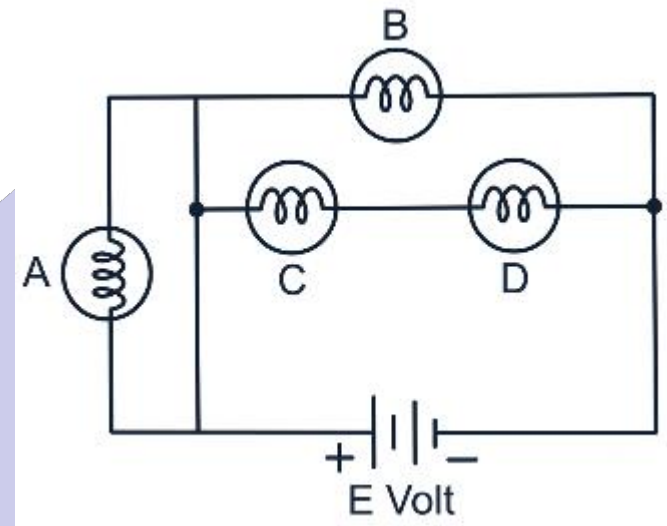


Figure for Question 8 (as printed in the paper).

(a) If the filament inside bulb C is broken, both the bulbs B and D continue to glow brightly

(b) If the filament inside bulb D is broken, bulb B goes off and bulb A glows

(c) If the filament of bulb A is broken, the event is unnoticeable; bulbs B, C, D remain glowing

(d) If the filament of bulb B is broken, both the bulbs C and D will go off

Solution

Correct option: C. **Method:** Bulb A is connected between the top and bottom wires on the left, and a plain connecting wire is joined in parallel with it. This wire short-circuits bulb A, so the potential difference across A is zero and A never glows. Bulb B is connected directly across the supply. Bulbs C and D are in series with each other, and this series combination is also connected directly across the supply (in parallel with B). So (a) is wrong (if C breaks, D goes off), (b) is wrong (if D breaks, B still glows and A still does not glow), and (d) is wrong (if B breaks, the C-D branch is still across the supply). Since A carries no current at any time, breaking its filament changes nothing.

Answer: (C).

Question 9 (Part A-1, single correct, +3 / -1)

The acceleration (a) - time (t) graph of a particle, moving in a straight line parallel to x axis, is shown in the figure (1). The correct velocity (v) - time (t) graph corresponding to the given acceleration-time graph for the motion of the particle is Figure (1): an acceleration-time graph. From 0 to t_1 the acceleration is constant and negative; from t_1

to t_2 it is constant and positive, of the same magnitude. The four option graphs are shown in the question paper PDF.

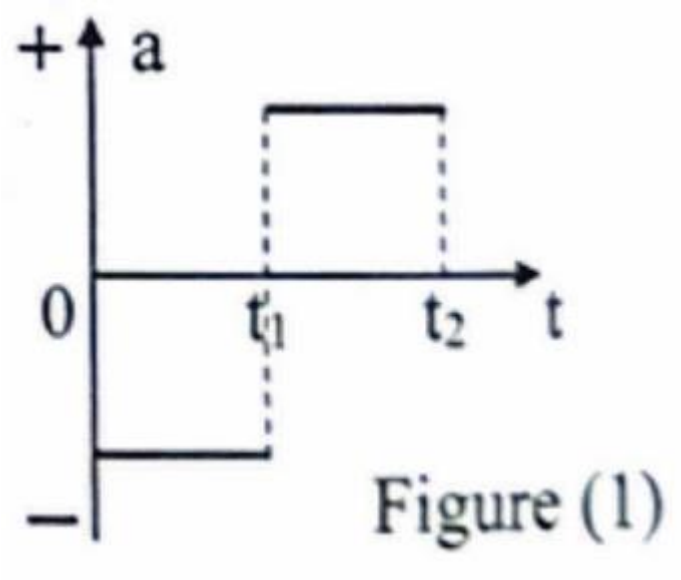


Figure for Question 9 (as printed in the paper).

(a) v rises linearly from zero to a peak at t1, then falls linearly back to zero at t2 (an inverted V shape)

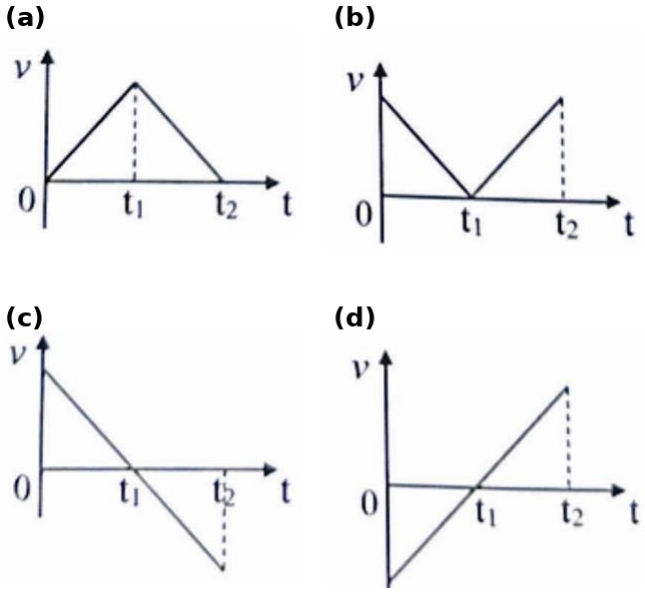
(b) v falls linearly from a positive value to zero at t1, then rises linearly to t2 (a V shape)

(c) v falls in a single straight line from a positive value, crossing zero near t1 and going below the axis by t2

(d) v rises in a single straight line from a negative value, crossing zero near t1 and rising above the axis by t2

Solution

Correct option: B. **Method:** Acceleration is the slope of the v-t graph (a = dv/dt). From 0 to t_1, a is constant and negative, so v decreases linearly with time (a straight line of negative slope). From t_1 to t_2, a is constant and positive, of the same magnitude, so v increases linearly with a positive slope of the same magnitude. Thus the v-t graph consists of two straight lines of equal and opposite slopes meeting at t_1 (a V shape). Only graph (b) shows this. Graph (a) is an inverted V; graphs (c) and (d) are single straight lines, which represent constant acceleration throughout.



The four v-t graphs (a) to (d).

Answer: (B).

Question 10 (Part A-1, single correct, +3 / -1)

In the ray diagrams shown below, the points L, F and C respectively represent the positions of lens, the focus and the centre of curvature on the principal axis of a convex lens. The correct pictorial representation (ray diagram) of the image formation by the convex lens for the given positions of the object and image is (The system is in air. The figures may not be scaled.) Figure: four ray diagrams (a) to (d) for a convex lens. L marks the lens, F the focus and C the centre of curvature (2F) on the principal axis. Each diagram shows an object arrow on the left and the rays after refraction.

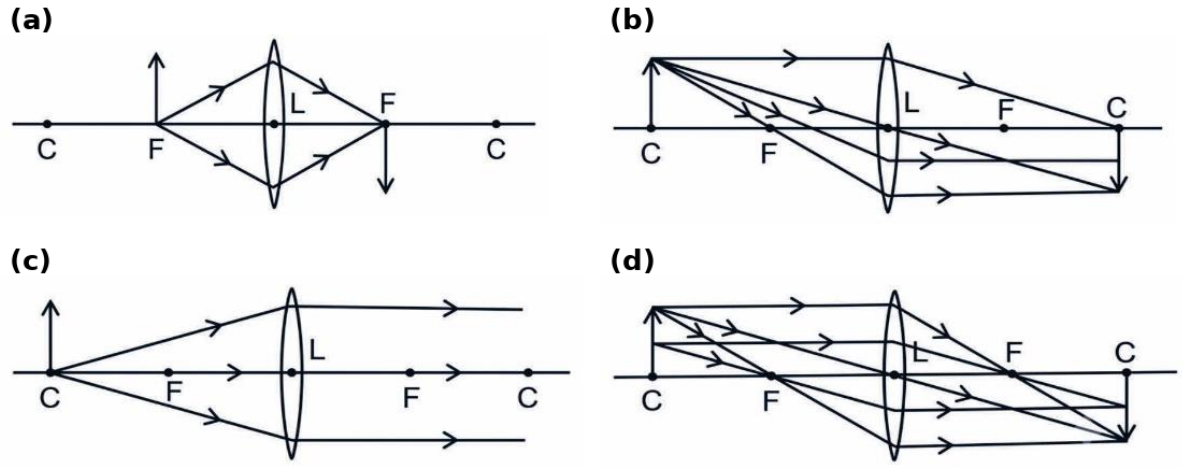


Figure for Question 10 (as printed in the paper).

(a) Object at F: rays from the tip of the object pass through the lens and meet at F on the other side, forming an inverted image at F

(b) Object at C: rays from the tip of the object pass through the lens and meet at the foot of the image on the axis, not at the tip of the image

(c) Object at C: rays from the tip of the object emerge parallel to the principal axis after passing through the lens

(d) Object at C: rays from the tip of the object pass through the lens and meet at the tip of a real, inverted, same-size image at C on the other side

Solution

Correct option: D. **Method:** For a convex lens: (i) a ray parallel to the principal axis passes through the second focus F after refraction; (ii) a ray passing through the first focus F emerges parallel to the principal axis; (iii) a ray through the optical centre L goes undeviated. For an object at C (= 2F), the image is formed at C (2F) on the other side; it is real, inverted and of the same size. (a) is wrong: an object at F gives refracted rays that become parallel, so the image is at infinity, not at F. (b) is wrong: the ray incident parallel to the axis is drawn after refraction towards the foot of the image on the axis, not through F to the tip of the image. (c) is wrong: the object is at C, but the refracted rays are drawn parallel (this happens only for an object at F). (d) is correct: all rays obey the rules above and meet at the tip of the real, inverted, same-size image at C.

Answer: (D).

Question 11 (Part A-1, single correct, +3 / -1)

A variable force F (in newton) acting on a body of mass m displaces it through displacement x (in meter) along a straight line in the direction of the force. The (F) vs displacement (x) graph is shown in figure. Change in the kinetic energy of the body, under the action of this force is Figure: a force-displacement graph. The force rises linearly from 0 to 10 N as x goes from 0 to 4 m, stays at 10 N from x = 4 m to x = 6 m, then falls linearly to zero at x = 7 m.

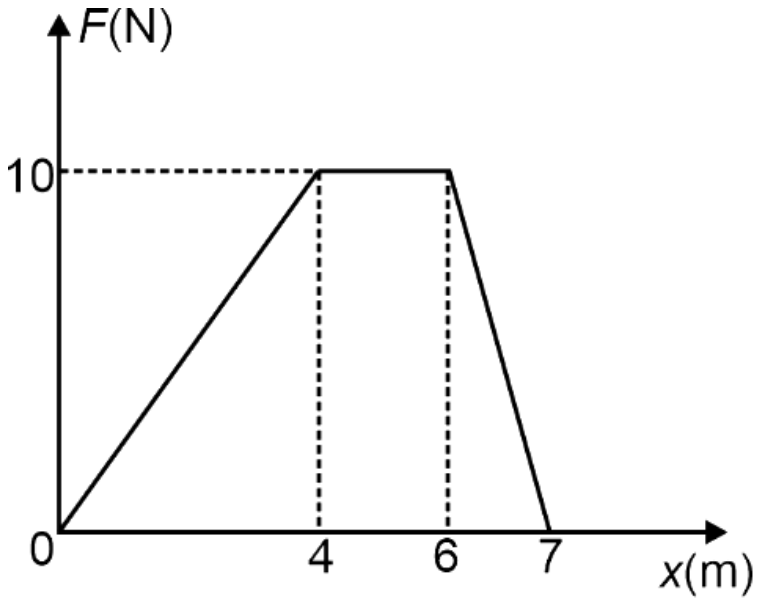


Figure for Question 11 (as printed in the paper).

(a) 70 J (b) 45 J (c) 35 J (d) Zero

Solution

Correct option: B. **Method:** By the work-energy theorem, the change in kinetic energy equals the work done, which is the area under the F-x graph. Area 1 (0 to 4 m, triangle) = (1/2) × 4 × 10 = 20 J. Area 2 (4 to 6 m, rectangle) = 2 × 10 = 20 J. Area 3 (6 to 7 m, triangle) = (1/2) × 1 × 10 = 5 J. Change in kinetic energy = 20 + 20 + 5 = 45 J.

Answer: (B).

Question 12 (Part A-1, single correct, +3 / -1)

A fine ray of white light is incident on the refracting surface of a transparent prism of angle A = 60° such that the angle of incidence (i) is 0 < i < 90. As a result of refraction, the light splits into its constituent colours. Hence the two statements: Statement-1, inside the prism, the blue light bends more than the red light. Statement-2, inside the prism, the blue light slows down more than red light. You may claim that the Figure: a triangular prism ABC with angle A = 60 degrees. A fine ray of white light is incident on face AB at an angle of incidence i, and splits into its constituent colours inside the prism.

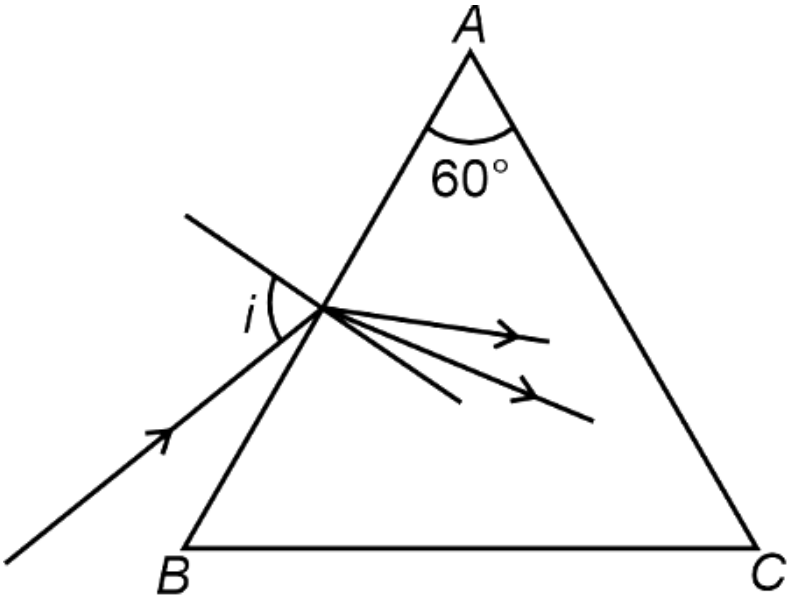


Figure for Question 12 (as printed in the paper).

(a) statement-1 and statement-2, are both true
(b) statement-1 is true but statement-2 is false
(c) statement-1 is false but the statement-2 is true
(d) statement-1 and statement-2, are both false

Solution

Correct option: A. **Method:** The refractive index of glass is greater for blue light than for red light ($n_{blue} > n_{red}$); this is the cause of dispersion. Statement-2: speed in the medium is v = c/n, so since $n_{blue} > n_{red}$, $v_{blue} < v_{red}$, so blue light slows down more. True. Statement-1: by Snell's law, sin r = sin i / n. For the same angle of incidence, larger n gives a smaller angle of refraction, so blue light bends more towards the normal (deviates more) than red light. True. Hence both statements are true.

Answer: (A).

Question 13 (Part A-1, single correct, +3 / -1)

In an experiment, four resistances of 6.0 ohm each are arranged in the circuit as shown below with a 4.0 V battery and an ammeter. The resistance of the ammeter and all connecting wires is negligible. The current recorded by the ammeter is Figure: a circuit with a 4 V battery and an ammeter in series at the bottom. Four 6 ohm resistors are connected above: three of them in parallel between two points P and Q, and the fourth in series with that combination.

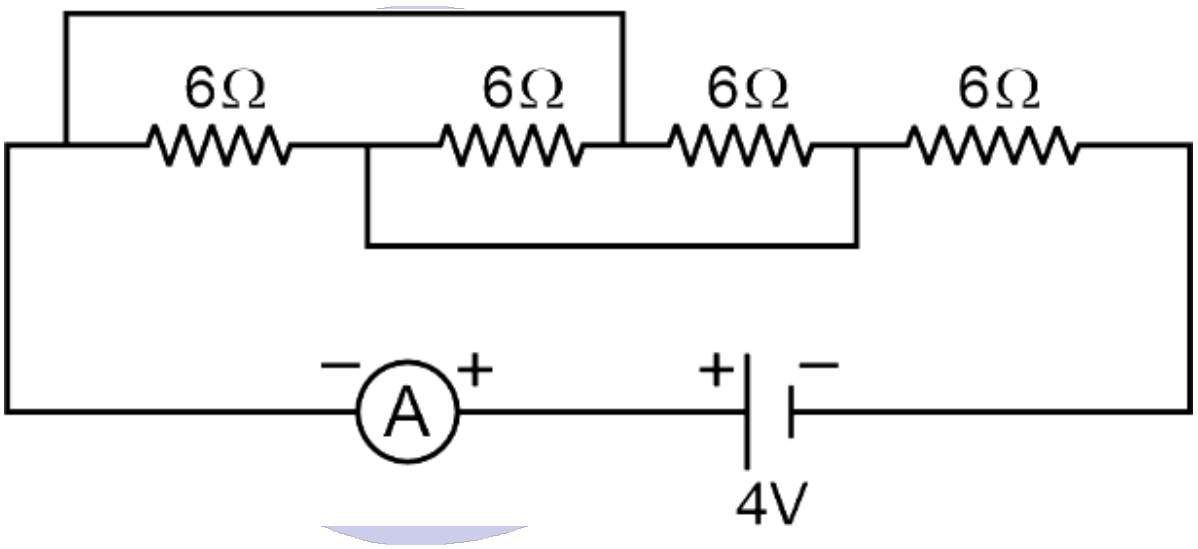


Figure for Question 13 (as printed in the paper).

(a) $\frac{1}{6}$ amp
(b) $\frac{1}{2}$ amp
(c) $\frac{2}{3}$ amp
(d) 2 amp

Solution

Correct option: B. **Method:** Three 6 ohm resistors in parallel between P and Q give $R_{PQ} = 6/3 = 2$ ohm. In series with the fourth 6 ohm resistor, the total resistance is $R_{eq} = 2 + 6 = 8$ ohm. The current is $I = V/R_{eq} = 4/8 = 1/2$ A.

Answer: (B).

Question 14 (Part A-1, single correct, +3 / -1)

In adjacent figure, a ray of light is incident on plane interface between medium-1 and medium-2 at an angle of incidence i = 30°. As a result of refraction, it travels in medium-2. The angle of refraction is θ, where $\sin\theta = \frac{2}{5}$. Absolute refractive index of medium-1 is $\frac{4}{3}$. Speed of light in vacuum is 3×10^8 ms^{-1}. The speed of light in medium-2 is Figure: a horizontal interface with medium-1 above and medium-2 below. A ray is incident from medium-1 at 30 degrees to the dashed normal, and refracts into medium-2 at an angle theta to the normal.

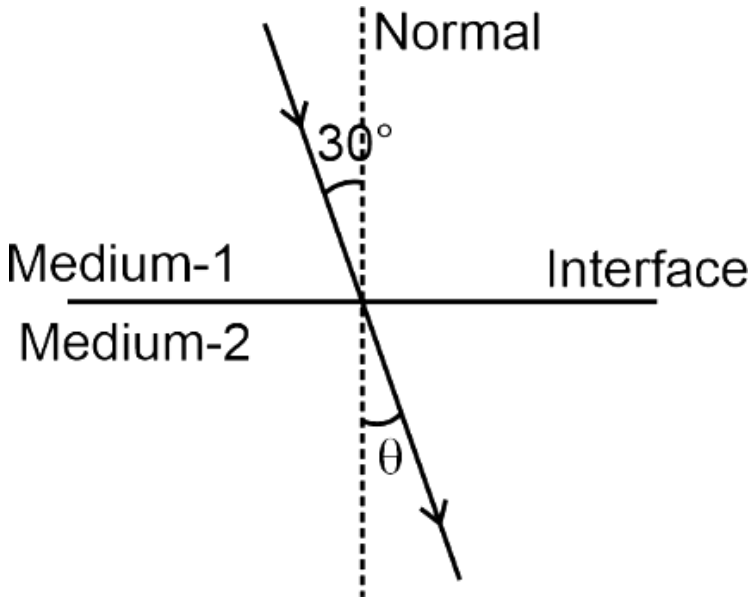


Figure for Question 14 (as printed in the paper).

(a) 2.25×10^8 ms^{-1} (b) 1.80×10^8 ms^{-1} (c) 1.40×10^8 ms^{-1} (d) 1.25×10^8 ms^{-1}

Solution

Correct option: B. **Method:** By Snell's law, $n_1 \sin i = n_2 \sin \theta$. So $(4/3) \times \sin 30° = n_2 \times (2/5)$, giving $(4/3) \times (1/2) = n_2 \times (2/5)$, so $n_2 = (2/3) \times (5/2) = 5/3$. The speed of light in medium-2 is $v_2 = c/n_2 = 3 \times 10^8/(5/3) = 1.80 \times 10^8$ ms^{-1}.

Answer: (B).

Question 15 (Part A-1, single correct, +3 / -1)

In the following circuit A is an ideal ammeter. The internal resistance of both the battery E_1 and E_2 is negligible. If the ammeter A reads zero current, the value of the resistance R must be Figure: a circuit with a battery $E_2 = 18$ V on the left in series with a 4000 ohm resistor, a resistor R in a middle vertical branch, and a battery $E_1 = 3$ V on the right in series with an ammeter A.

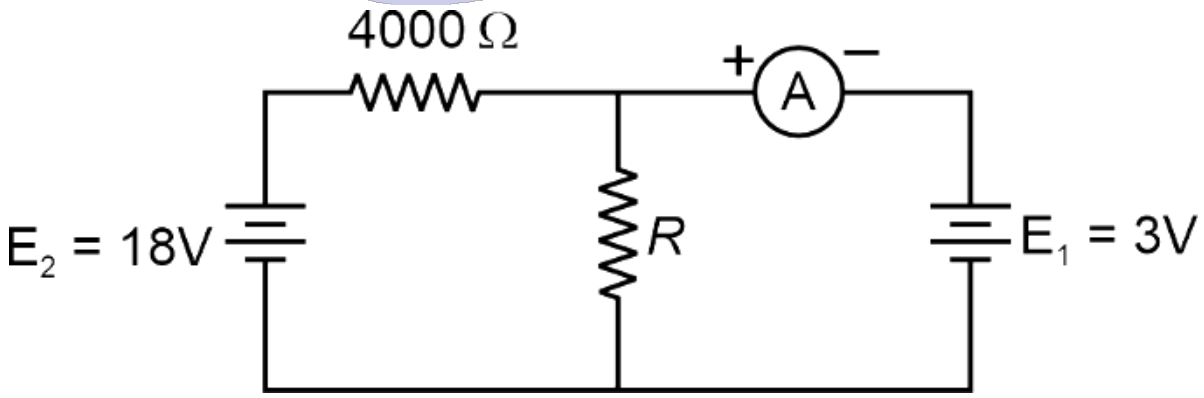


Figure for Question 15 (as printed in the paper).

(a) 1000 ohm (b) 800 ohm (c) 500 ohm (d) 2000 ohm

Solution

Correct option: B. **Method:** Since the ammeter reads zero, no current flows in the branch containing E_1. Hence there is no potential drop in that branch and the potential difference across R equals $E_1 = 3$ V. The same current I flows through the 4000 ohm resistor and R (the loop containing E_2): $I = E_2/(4000 + R) = 18/(4000 + R)$. The

potential difference across R is IR = 3, so 18R/(4000 + R) = 3, giving 18R = 12000 + 3R, so R = 800 ohm. Check: I = 18/4800 = 3.75 mA; the drop across 4000 ohm is 15 V and across R is 3 V, equal to E_1.

Answer: (B).

Question 16 (Part A-1, single correct, +3 / -1)

During restoration of an archaeological site, workers use a 1.5 m long lever to lift a big stone of mass 120 kg. The load is positioned 0.30 m from the fulcrum. The minimum effort required to lift the stone is

(a) 1176.4 N (b) 294.0 N (c) 235.2 N (d) 36.0 N

Solution

Correct option: C. **Method:** Load W = mg = 120 × 9.8 = 1176 N; load arm = 0.30 m. By the principle of moments (law of lever), effort × effort arm = load × load arm. The effort is minimum when the effort arm is maximum, that is, when the effort is applied at the free end of the lever, at 1.5 m from the fulcrum (fulcrum at one end and the load between the fulcrum and the effort). So E_{min} = 1176 × 0.30 / 1.5 = 235.2 N. (If the fulcrum were placed between the load and the effort, the effort arm would be only 1.5 - 0.3 = 1.2 m, giving 294 N, which is not the minimum.)

Answer: (C).

Question 17 (Part A-1, single correct, +3 / -1)

If N is the population of a country at a certain time t then which of the following refers to the absolute growth rate of a population?

(a) $\frac{\Delta N}{N}/\Delta t$ (b) $\frac{\Delta N}{\Delta t}$ (c) $\frac{\Delta t}{N}$ (d) $\frac{1}{N} \times \frac{\Delta N}{\Delta t}$

Solution

Correct option: B. **Method:** The absolute growth rate of a population is the raw rate at which the population is increasing or decreasing over a specific time interval, given by ΔN/Δt. The per capita (relative) growth rate is (1/N) × (ΔN/Δt), which is option (d), not the absolute growth rate.

Answer: (B).

Question 18 (Part A-1, single correct, +3 / -1)

One of the following is a vasodilator, produced by the mast cells and many other tissues like liver, lung muscles etc. Choose the correct option:

(a) Serotonin (b) Histamine (c) Prostacyclin (d) Bradykinin

Solution

Correct option: B. **Method:** Histamine is a chemical mediator synthesised and stored primarily in mast cells and basophils, as well as in tissues like the liver, lungs and skin. It acts as a potent vasodilator. (Serotonin is mainly a vasoconstrictor; prostacyclin and bradykinin are also vasodilators but are not the mast-cell mediator asked for here.)

Answer: (B).

Question 19 (Part A-1, single correct, +3 / -1)

Folds of Kerckring are anatomical characteristics to which of the following?

(a) Bile duct (b) Ureter (c) Intestine (d) Bronchii

Solution

Correct option: C. **Method:** The folds of Kerckring (circular folds) are large, circular folds of the mucous membrane found in the small intestine. They increase the surface area available for nutrient absorption.

Answer: (C).

Question 20 (Part A-1, single correct, +3 / -1)

Given below are two statements, one labeled as Assertion A and other labeled as Reason R. Assertion (A): The difference in electric potential on the two sides of the nerve fibre membrane is termed the membrane potential which is about -0.07 volt or -70 mV. Reason (R): The extracellular fluid (ECF) has a high concentration of K+ and Cl- and the intracellular fluid has a high concentration of Na+ and HCO3-. Select the correct answer from the codes given below: (a) Both A and R are true and R is the correct explanation of A; (b) Both A and R are true but R is not the correct explanation of A; (c) A is true but R is false; (d) R is true but A is false.

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true but R is not the correct explanation of A

(c) A is true but R is false

(d) R is true but A is false

Solution

Correct option: C. **Method:** Assertion (A) is true: the resting membrane potential is about -70 mV. Reason (R) is false: the extracellular fluid (ECF) has a high concentration of Na+ and Cl-, whereas the intracellular fluid (ICF) has a high concentration of K+ and negatively charged proteins. The statement in (R) has the two fluids swapped.

Answer: (C).

Question 21 (Part A-1, single correct, +3 / -1)

Keeping in mind climatic factors, disease and pest resistance, quality, yield and adaptability etc, a large number of varieties of crops have been developed in India. Make the correct matches of the following. Column I (varieties): 1. Heera, Jawahar, PNR-591; 2. RLM-514, Kranti, Pusa Bold; 3. K-850, ICC-34, BE-244; 4. Ganga-5, Navjot, Vikram. Column II (crops): (i) Gram; (ii) Maize; (iii) Rice; (iv) Mustard. Choose the correct option:

(a) 1-(ii), 2-(i), 3-(iv), 4-(iii)

(b) 1-(iii), 2-(iv), 3-(i), 4-(ii)

(c) 1-(i), 2-(ii), 3-(iii), 4-(iv)

(d) 1-(iv), 2-(iii), 3-(i), 4-(ii)

Solution

Correct option: B. **Method:** 1. Heera, Jawahar, PNR-591 are rice varieties, so 1-(iii). 2. RLM-514, Kranti, Pusa Bold are mustard varieties, so 2-(iv). 3. K-850, ICC-34, BE-244 are gram (chickpea) varieties, so 3-(i). 4. Ganga-5, Navjot, Vikram are maize varieties, so 4-(ii). The correct sequence is 1-(iii), 2-(iv), 3-(i), 4-(ii).

Answer: (B).

Question 22 (Part A-1, single correct, +3 / -1)

Study the following diagram and its functional antomical details. One important part of its structual constituent is labeled with 'question (?) mark', playing an important role in the physiology of mammals. What function can be correlated with the 'question (?) marked' part. Choose the correct option: Figure: a diagram of the human ribcage seen from the front, with the muscles between the ribs marked with a question (?) mark on the right side.

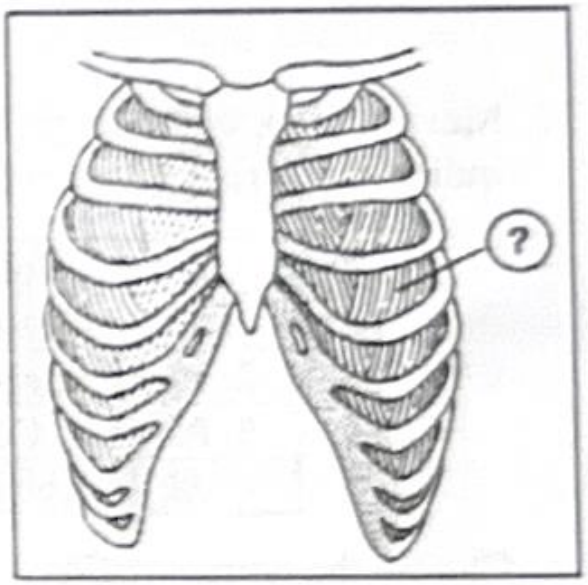


Figure for Question 22 (as printed in the paper).

(a) Their action draws the ribs downwards.

(b) Their action draws the ribs both downwards and outwards.

(c) Their action raises the ribs upwards and inwards.

(d) Their action raises the ribs upwards and outwards.

Solution

Correct option: D. **Method:** The question mark (?) represents the external intercostal muscles, the muscles between the ribs. The primary function of the external intercostal muscles is to elevate the ribs and sternum upwards and outwards during inhalation, increasing the volume of the chest cavity.

Answer: (D).

Question 23 (Part A-1, single correct, +3 / -1)

Some plants have scotoactive stomata. Such plants have:

(a) C_3 pathway of photosynthesis

(b) Photosynthesize by Calvin-Benson pathways

(c) Crassulacean Acid Metabolism pathways of photosynthesis

(d) C_4 pathways of photosynthesiss

Solution

Correct option: C. **Method:** Scotoactive stomata are specialised stomata that remain closed during the day to prevent water loss through transpiration and open at night to take in carbon dioxide. Succulent and desert plants (such as cacti, Opuntia and pineapple) possess scotoactive stomata and perform Crassulacean Acid Metabolism (CAM) photosynthesis.

Answer: (C).

Question 24 (Part A-1, single correct, +3 / -1)

Make the correct matches of the following. Column I (foramina): 1. Obturator Foramen; 2. Mental Foramen; 3. Foramen Ovale; 4. Foramina of Luschka. Column II (location): (i) Brain; (ii) Pelvic Girdle; (iii) Mandible; (iv) Skull. Choose the correct option:

(a) 1-(iv), 2-(i), 3-(iii), 4-(ii)

(b) 1-(ii), 2-(iv), 3-(i), 4-(iii)

(c) 1-(ii), 2-(iii), 3-(iv), 4-(i)

(d) 1-(iii), 2-(ii), 3-(i), 4-(iv)

Solution

Correct option: C. **Method:** 1. Obturator Foramen is a large opening in the hip bone of the Pelvic Girdle, so 1-(ii). 2. Mental Foramen is an opening on the anterior surface of the Mandible (lower jaw), so 2-(iii). 3. Foramen Ovale is an opening in the sphenoid bone at the base of the Skull, so 3-(iv). 4. Foramina of Luschka are lateral openings in the fourth ventricle of the Brain that allow cerebrospinal fluid to flow into the subarachnoid space, so 4-(i). The correct sequence is 1-(ii), 2-(iii), 3-(iv), 4-(i).

Answer: (C).

Question 25 (Part A-1, single correct, +3 / -1)

What is the difference between a disinfectant and an antiseptic?

(a) A disinfectant kills bacterial spores, while an antiseptic does not.

(b) A disinfectant is used on lifeless objects only, while an antiseptic is used on the skin surface.

(c) A disinfectant does not get sterilized, while an antiseptic does.

(d) Disinfectants are chemical substances, while antiseptics are not.

Solution

Correct option: B. **Method:** Antiseptics are antimicrobial agents safe to apply to living tissues (such as skin, cuts and wounds), whereas disinfectants are stronger formulations meant strictly for inanimate (lifeless) objects like floors, instruments and drainage systems because they can harm living tissue.

Answer: (B).

Question 26 (Part A-1, single correct, +3 / -1)

Study the following diagrams labeled 1 to 6. Which of the following options shows the correct sequence of labeled numbers related with the plants, namely- Tagetes, Cucurbita, Solanum, Nymphaea, Dianthus and Lathyrus?
Figure: six cross-sections of ovaries labeled 1 to 6, showing different arrangements of the ovules inside. 1 is a narrow pod with one ovule; 2 is a round section with ovules in the centre; 3 is a round section with ovules spread over the inner surface; 4 is a round section divided into chambers with ovules on the central axis; 5 is a round section with ovules on the wall; 6 is a tall pod with a single ovule at the base.

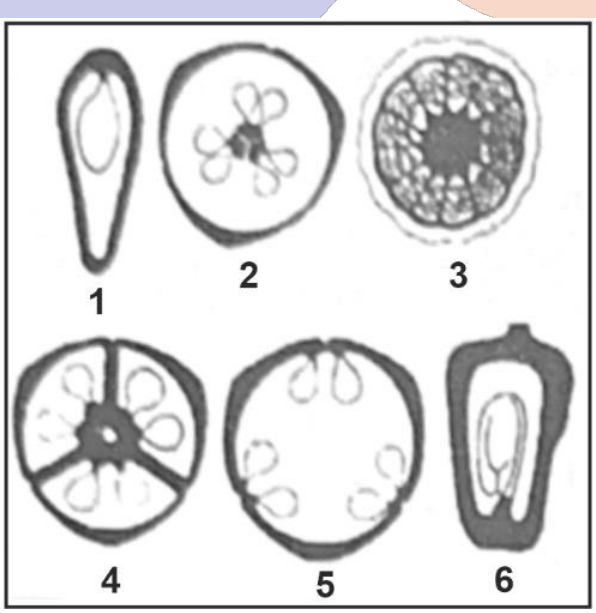


Figure for Question 26 (as printed in the paper).

(a) 1, 3, 4, 2, 5 and 6 (b) 6, 5, 4, 3, 2 and 1 (c) 5, 6, 3, 1, 2 and 4 (d) 2, 4, 5, 3, 1 and 2

Solution

Correct option: B. **Method:** The type of placentation in each diagram is: 1 Marginal (Lathyrus); 2 Free-central (Dianthus); 3 Superficial (Nymphaea, water lily); 4 Axile (Solanum); 5 Parietal (Cucurbita); 6 Basal (Tagetes). The plants in the order asked are Tagetes (6), Cucurbita (5), Solanum (4), Nymphaea (3), Dianthus (2) and Lathyrus (1), so the correct sequence is 6, 5, 4, 3, 2 and 1.

Answer: (B).

Question 27 (Part A-1, single correct, +3 / -1)

Make the correct matches of the following. Column I (receptors): 1. End Bulbs of Krause; 2. End Organs of Ruffini; 3. Pacinian Corpuscles; 4. Algesireceptors. Column II (types or functions): (i) Pain Receptors; (ii) Pressure Receptors; (iii) Caloreceptors; (iv) Frigidoreceptors. Choose the correct option:

(a) 1-(i), 2-(iii), 3-(ii), 4-(iv)
(b) 1-(iii), 2-(i), 3-(iv), 4-(ii)
(c) 1-(iv), 2-(iii), 3-(ii), 4-(i)
(d) 1-(iv), 2-(ii), 3-(i), 4-(iii)

Solution

Correct option: C. **Method:** 1. End Bulbs of Krause are thermoreceptors in the dermis that detect cold, so 1-(iv) Frigidoreceptors. 2. End Organs of Ruffini are thermoreceptors deep in the dermis that detect warmth (and skin stretch), so 2-(iii) Caloreceptors. 3. Pacinian Corpuscles are mechanoreceptors sensitive to deep pressure and high-frequency vibration, so 3-(ii) Pressure Receptors. 4. Algesireceptors (nociceptors) are sensory nerve endings that respond to tissue damage and pain, so 4-(i) Pain Receptors. The correct sequence is 1-(iv), 2-(iii), 3-(ii), 4-(i).

Answer: (C).

Question 28 (Part A-1, single correct, +3 / -1)

Suppose there is no anthropogenic pollution, the concentration of CO_2 in the atmosphere would remain relatively constant, because:

(a) In photoautotrophs, the rate of photosynthesis is equal to the rate of their cellular respiration.
(b) During photosynthesis, CO2 is consumed and O2 is released.
(c) The rate of photosynthesis by photoautotrophs is about equal to the rate of cellular respiration by all organisms.
(d) In plants, photosynthesis occurs during the day and cellular respiration at night.

Solution

Correct option: C. **Method:** Without human-caused (anthropogenic) emissions, atmospheric CO_2 stays steady because the amount of CO_2 absorbed from the atmosphere by photoautotrophs during photosynthesis roughly equals the total amount of CO_2 released back into the atmosphere through cellular respiration by all organisms. Option (a) is too narrow (only the photoautotrophs' own respiration), (b) states a fact but not the balance, and (d) is wrong (respiration goes on day and night).

Answer: (C).

Question 29 (Part A-1, single correct, +3 / -1)

Deciduous teeth in human beings fall out generally between the age of 6 and 13 years. What is the approximate age at which permanent Canines erupt?

(a) 5 to 8 years (b) 9 to 14 years (c) 7 to 24 years (d) 8 to 10 years

Solution

Correct option: B. **Method:** Permanent canines are the pointed teeth next to the lateral incisors. They replace the deciduous canines during permanent dentition. Permanent lower canines generally erupt around 9-10 years of age,

and permanent upper canines around 11-12 years of age. So the eruption period falls within the range of 9-14 years.

Answer: (B).

Question 30 (Part A-1, single correct, +3 / -1)

Larger subunit of ribosomes (60S) in eukaryotic plants involves which of the following RNA composition?

(a) 25S + 5S + 5.8S (b) 28-29S + 5S + 5.8S (c) 23S + 5.8S (d) 28S + 16-17S + 5S

Solution

Correct option: A. **Method:** In eukaryotic plants, the larger subunit of the ribosome (60S) consists of 25S, 5S and 5.8S rRNA. (Animals have 28S instead of 25S in the large subunit; 23S and 16S are prokaryotic.)

Answer: (A).

Question 31 (Part A-1, single correct, +3 / -1)

Which of the following statements best describes the primary function of lenticels in woody plants?

(a) To facilitate the process of guttation during periods of high humidity.

(b) To allow for gaseous exchange between the internal tissues of the stem and the atmosphere.

(c) To provide structural support to the secondary xylem in aging trees.

(d) To facilitate the formation of phellogen.

Solution

Correct option: B. **Method:** Lenticels are lens-shaped, porous openings in the periderm (bark) of woody stems and roots, filled with loosely arranged complementary cells. They allow oxygen and carbon dioxide to diffuse between the atmosphere and living internal stem tissues. (Guttation happens through hydathodes, not lenticels.)

Answer: (B).

Question 32 (Part A-1, single correct, +3 / -1)

To prevent hemolytic disease of the newborn from occurring in a successive pregnancy, Rh negative woman giving birth to Rh positive child will receive shortly after birth an injection of

(a) A and B factors (b) Type O blood (c) Rh antibodies (d) Rh antigens

Solution

Correct option: C. **Method:** During delivery of an Rh+ baby, small amounts of fetal blood can enter the Rh- mother's bloodstream. To prevent her immune system from becoming sensitised and making permanent memory cells, she is given an injection of anti-Rh antibodies within 72 hours of birth. These injected antibodies bind to and destroy the fetal Rh+ red blood cells before the mother's own immune system can react to them.

Answer: (C).

Question 33 (Part A-1, single correct, +3 / -1)

A compound X is observed to decolourise bromine water and reacts with sodium metal to release hydrogen gas. Which functional group(s) is/are present in that compound?

(a) Aldehyde (-CHO) only

(b) Alkene (C=C) only

(c) Both an alkene (C=C) and a hydroxyl (-OH) group

(d) Carboxylic acid (-COOH) only

Solution

Correct option: C. **Method:** Decolourisation of bromine water is the test for unsaturation (C=C): bromine adds across the double bond and the reddish-brown colour disappears. Liberation of H_2 with sodium shows an acidic hydrogen, that is, an -OH group. An alkene alone does not react with Na; an aldehyde alone does not liberate H_2 with Na; a carboxylic acid alone does not decolourise bromine water. Hence X contains both C=C and -OH (for example, allyl alcohol, CH_2=CH-CH_2OH).

Answer: (C).

Question 34 (Part A-1, single correct, +3 / -1)

Which of the following represents an anhydride for two acids?

(a) N_2O (b) NO_2 (c) SO_2 (d) SO_3

Solution

Correct option: B. **Method:** NO_2 is a mixed anhydride: on dissolving in water it gives two acids, nitrous acid and nitric acid: $2NO_2 + H_2O$ gives $HNO_2 + HNO_3$. N_2O is a neutral oxide; SO_2 gives only H_2SO_3; SO_3 gives only H_2SO_4.

Answer: (B).

Question 35 (Part A-1, single correct, +3 / -1)

A currency counting machine counts 6.023 million notes per day. A bank has as many notes as number of oxygen atoms in 24.8 g of $Na_2S_2O_3 . 5H_2O$. How many days would be required to count these notes?

(a) 10^6 (b) 15×10^{15} (c) 8×10^{16} (d) None of these

Solution

Correct option: C. **Method:** Molar mass of $Na_2S_2O_3 . 5H_2O = 2(23) + 2(32) + 3(16) + 5(18) = 46 + 64 + 48 + 90 = 248$ g mol^{-1}. Moles in 24.8 g = 24.8/248 = 0.1 mol. Oxygen atoms per formula unit = 3 (in $S_2O_3^{2-}$) + 5 (in $5H_2O$) = 8. Number of O atoms = $0.1 \times 8 \times 6.023 \times 10^{23} = 0.8 \times 6.023 \times 10^{23}$. Number of days = $(0.8 \times 6.023 \times 10^{23})/(6.023 \times 10^6) = 0.8 \times 10^{17} = 8 \times 10^{16}$ days.

Answer: (C).

Question 36 (Part A-1, single correct, +3 / -1)

The volume of HCl produced, when 32 g of CH_4 is allowed to react with excess chlorine is

(a) 8.96 L (b) 89.6 L (c) 179.2 L (d) 22.4 L

Solution

Correct option: C. **Method:** With excess chlorine (in diffused sunlight), substitution continues until all four hydrogen atoms of methane are replaced: $CH_4 + 4Cl_2$ gives $CCl_4 + 4HCl$. Moles of CH_4 = 32/16 = 2 mol, so moles of HCl = 4 × 2 = 8 mol. Volume of HCl at STP = 8 × 22.4 L = 179.2 L.

Answer: (C).

Question 37 (Part A-1, single correct, +3 / -1)

How many grams of acetic acid will be produced when 92 g of ethanol is completely oxidized, if the reaction has 80% yields?

(a) 120 g (b) 60 g (c) 96 g (d) 80 g

Solution

Correct option: C. **Method:** Oxidation of ethanol by alkaline $KMnO_4$ or acidified $K_2Cr_2O_7$: $CH_3CH_2OH + 2[O]$ gives $CH_3COOH + H_2O$. Moles of ethanol = 92/46 = 2 mol, so theoretical acetic acid = 2 mol = 2 × 60 = 120 g. Actual yield = 80% of 120 g = 96 g.

Answer: (C).

Question 38 (Part A-1, single correct, +3 / -1)

What is the molar mass of water if it contains 50% heavy water (D_2O)?

(a) 9 g (b) 18 g (c) 19 g (d) 10 g

Solution

Correct option: C. **Method:** Molar mass of H_2O = 18 g mol^{-1}; molar mass of D_2O = 2(2) + 16 = 20 g mol^{-1}. Average molar mass of the 50 : 50 (mole) mixture = 0.5 × 18 + 0.5 × 20 = 19 g mol^{-1}.

Answer: (C).

Question 39 (Part A-1, single correct, +3 / -1)

During the reaction of zinc with concentrated sodium hydroxide solution, hydrogen gas is evolved. This dissolved zinc is present in solution as

(a) ZnO (b) $Na_2[Zn(H_2O)_6]$ (c) $Na_2[Zn(OH)_4]$ (d) $Zn(OH)_2$

Solution

Correct option: C. **Method:** Zinc is amphoteric and dissolves in concentrated alkali to form soluble sodium zincate, liberating hydrogen: $Zn + 2NaOH + 2H_2O$ gives $Na_2[Zn(OH)_4] + H_2$. In solution the zinc is present as the tetrahydroxozincate (II) ion, $[Zn(OH)_4]^{2-}$.

Answer: (C).

Question 40 (Part A-1, single correct, +3 / -1)

Select the incorrect matches: A. Burning of LPG - Exothermic reaction; B. Photosynthesis - Endothermic reaction; C. Reaction of Zinc with dilute HCl - Displacement reaction; D. Rusting of Iron - Decomposition reaction; E. Decomposition of vegetable matter into compost - Endothermic reaction.

(a) A and C (b) B, C and E (c) D and E (d) B, D and E

Solution

Correct option: C. **Method:** A is correct (burning LPG releases heat). B is correct (photosynthesis absorbs sunlight). C is correct (zinc displaces hydrogen from dilute HCl). D is incorrect: rusting ($4Fe + 3O_2 + 2xH_2O$ gives $2Fe_2O_3.xH_2O$) is an oxidation (combination) reaction, not decomposition. E is incorrect: decomposition of vegetable matter into compost releases heat, so it is exothermic, not endothermic. The incorrect matches are D and E.

Answer: (C).

Question 41 (Part A-1, single correct, +3 / -1)

Arrange the hydrogens in increasing order of their acidic strength: Figure: a six-membered ring with a ketone C=O at the top, a C=C double bond on the left side, an H_A-O- group on the upper left carbon, an H_B-O- group on the lower left carbon, and an O-H_C group on the bottom carbon.

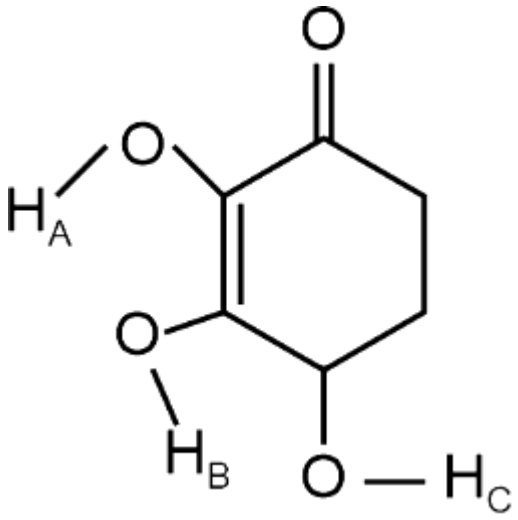


Figure for Question 41 (as printed in the paper).

(a) A > B > C (b) B > A > C (c) C > B > A (d) C > A > B

Solution

Correct option: B. **Method:** Acidic strength follows the stability of the conjugate base. The conjugate base of B is involved in extended conjugation (the negative charge delocalises over the conjugated enone system), so it is the most stable and B is the most acidic. The conjugate base of A is involved in a single resonance (delocalisation to the carbonyl oxygen). The conjugate base of C is an ordinary alkoxide with no resonance. So the order is B > A > C.

Answer: (B).

Question 42 (Part A-1, single correct, +3 / -1)

Five test tubes (I-V) contain the following reacting substances: I. Ethanol + Sodium metal; II. Ethanoic acid + Sodium carbonate; III. Ethanoic acid + Sodium hydroxide; IV. Ethanoic acid + Sodium hydrogen carbonate; V. Ethyl ethanoate + Sodium hydroxide. A burning matchstick is brought near the mouth of each test tube. In which of the test tubes will the flame be extinguished?

(a) II, IV and V (b) I and V only (c) II and IV only (d) II, III and IV

Solution

Correct option: C. **Method:** The flame is extinguished only by carbon dioxide (it neither burns nor supports combustion). I: $2C_2H_5OH + 2Na$ gives $2C_2H_5ONa + H_2$ (H_2 burns with a pop; flame not extinguished). II: $2CH_3COOH + Na_2CO_3$ gives $2CH_3COONa + H_2O + CO_2$. III: $CH_3COOH + NaOH$ gives $CH_3COONa + H_2O$ (neutralisation; no gas). IV: $CH_3COOH + NaHCO_3$ gives $CH_3COONa + H_2O + CO_2$. V: $CH_3COOC_2H_5 + NaOH$ gives $CH_3COONa + C_2H_5OH$ (saponification; no gas). CO_2 is evolved only in II and IV.

Answer: (C).

Question 43 (Part A-1, single correct, +3 / -1)

A blue $CuSO_4$ solution is evaporated to dryness and heated strongly (about 230 degrees) until it becomes white. The oxidation state of copper throughout the process is

(a) +2 to +1 (b) +2 to +3 (c) +2 to 0 (d) +2 only

Solution

Correct option: D. **Method:** On evaporation, blue crystals of $CuSO_4.5H_2O$ are obtained. Strong heating (about 230°C) removes the water of crystallisation: $CuSO_4.5H_2O$ (blue) gives $CuSO_4$ (white, anhydrous) + $5H_2O$. This is only dehydration; no oxidation or reduction occurs. Copper remains in the +2 oxidation state throughout.

Answer: (D).

Question 44 (Part A-1, single correct, +3 / -1)

Which of the following metal ions is expected to be coloured?

(a) Zn^{2+} (b) Ti^{3+} (c) Sc^{3+} (d) Ti^{4+}

Solution

Correct option: B. **Method:** Colour of transition metal ions arises from d-d transitions, which require partly filled d-orbitals. Zn^{2+} is $3d^{10}$; Sc^{3+} is $3d^0$; Ti^{4+} is $3d^0$. No d-d transition is possible in these, so they are colourless. Ti^{3+} is $3d^1$ with one unpaired d electron; a d-d transition absorbs visible light, so $[Ti(H_2O)_6]^{3+}$ is violet/purple.

Answer: (B).

Question 45 (Part A-1, single correct, +3 / -1)

Between Li+ and H- which is assumed to have larger ionic radius:

(a) Li+ (b) H-

(c) Both contain two electrons and are of same size (d) Depends upon the counter ion

Solution

Correct option: B. **Method:** Li+ and H- are isoelectronic (2 electrons each, $1s^2$). For isoelectronic species, the size decreases as the nuclear charge increases. Li+ has Z = 3, while H- has Z = 1, so the two electrons of H- are held much less tightly (and also repel each other more effectively). Hence H- is much larger than Li+.

Answer: (B).

Question 46 (Part A-1, single correct, +3 / -1)

A complex ion has magnetic moment 4.90 BM. It is supposed to be:

(a) $[Cr(NH_3)_6]^{3+}$ (b) $[Fe(CN)_6]^{4-}$ (c) $[Ni(CN)_4]^{2-}$ (d) $[Fe(H_2O)_6]^{2+}$

Solution

Correct option: D. **Method:** Spin-only magnetic moment is $\mu = \sqrt{(n(n+2))}$ BM. $4.90 = \sqrt{24}$, so $n(n+2) = 24$ and n = 4 unpaired electrons. $[Cr(NH_3)_6]^{3+}$: Cr^{3+}, $3d^3$, n = 3, μ = 3.87 BM. $[Fe(CN)_6]^{4-}$: Fe^{2+}, $3d^6$, CN- is a strong field ligand, so low spin t_{2g}^6, n = 0 (diamagnetic). $[Ni(CN)_4]^{2-}$: Ni^{2+}, $3d^8$, square planar (dsp^2), n = 0 (diamagnetic). $[Fe(H_2O)_6]^{2+}$: Fe^{2+}, $3d^6$, H_2O is a weak field ligand, n = 4, μ = 4.90 BM.

Answer: (D).

Question 47 (Part A-1, single correct, +3 / -1)

AgO actually exists as $Ag[AgO_2]$, which is diamagnetic in nature. Then which of the following statements is correct regarding AgO?

(a) The arrangement of O^{2-} ions around Ag+ ion is square planar.

(b) The arrangement of O^{2-} ions around Ag^{3+} ion is tetrahedral.

(c) The arrangement of O^{2-} ions around Ag+ ion is tetrahedral.

(d) The arrangement of O^{2-} ions around Ag^{3+} ion is square planar.

Solution

Correct option: D. **Method:** In $Ag[AgO_2]$ (that is, $Ag^{I}Ag^{III}O_2$), the average oxidation state +2 is shared as one Ag+ and one Ag^{3+}. Ag+ is $4d^{10}$, always diamagnetic, and in AgO it is linearly coordinated by two O^{2-} ions. Ag^{3+} is $4d^8$; in a tetrahedral field a d^8 ion has two unpaired electrons (paramagnetic). For the compound to be diamagnetic, the eight d electrons must be paired, which happens in a square planar (dsp^2) arrangement. Hence the O^{2-} ions are arranged in a square planar manner around Ag^{3+}.

Answer: (D).

Question 48 (Part A-1, single correct, +3 / -1)

Which of the following may liberate O_2 from water?

(a) Cl_2 (b) CaH_2 (c) F_2 (d) None of these

Solution

Correct option: C. **Method:** Fluorine is the strongest oxidising agent; it oxidises water to oxygen: $2F_2 + 2H_2O$ gives $4HF + O_2$ (some O_3 is also formed). Chlorine reacts with water to give HCl and HOCl ($Cl_2 + H_2O$ gives HCl + HOCl) and does not liberate O_2 directly; calcium hydride liberates hydrogen: $CaH_2 + 2H_2O$ gives $Ca(OH)_2 + 2H_2$.

Answer: (C).

PART A-2

Question 49 (Part A-2, multi correct, 6 marks, all-or-nothing)

Brass is an alloy of Copper and Zinc containing Copper and Zinc in a specific ratio. A cube of brass weighs 516 gram-weight in air. When completely immersed in water, it weighs 452 gram-weight. Density of water = 1.0 g/cc, Relative density of Copper = 8.9, Relative density of Zinc = 7.1. The correct option(s) is/are

(a) The edge of the cube is 4.0 cm

(b) The mass of Copper contained in the cube is 304.58 gram

(c) The mass of Zinc contained in the cube is 206.40 gm

(d) The mass ratio of Copper and Zinc is in the cube is 60 : 40

Solution

Correct options: A, B. **Method:** Volume: by Archimedes' principle, loss of weight = weight of water displaced = 516 - 452 = 64 g-wt. Volume of cube V = 64 g / (1.0 g cm^{-3}) = 64 cm^3, so edge a = 4.0 cm. Option (a) is correct. Composition: let mass of copper = x g; mass of zinc = (516 - x) g. Total volume = sum of volumes of the two metals: x/8.9 + (516 - x)/7.1 = 64. Multiplying by 8.9 × 7.1 = 63.19: 7.1x + 8.9(516 - x) = 4044.16, so 4592.4 - 1.8x = 4044.16 and x = 304.58 g. Mass of copper = 304.58 g (option (b) correct); mass of zinc = 516 - 304.58 = 211.42 g, so option (c), 206.40 g, is incorrect. Mass ratio Cu : Zn = 304.58 : 211.42, about 59 : 41, not 60 : 40, so option (d) is incorrect.

Answer: (A), (B).

Question 50 (Part A-2, multi correct, 6 marks, all-or-nothing)

A driver starts a DTC bus in Delhi from sector-1, RK Puram bus stop and accelerates it at a constant rate a_1 for 10 second. During this time, the bus travels 100 meter. The bus continues to move at a constant velocity v for one minute. When the driver notices a red light 100 meter ahead and applies brake. The bus moves further with constant deceleration a_2 and finally comes to a stop just at the red light. If the bus travels in a straight line all the way, you may conclude that

(a) the velocity of the bus after first 10 seconds is 20 ms^{-1}

(b) the average speed of the bus, during the entire journey, is 17.5 ms^{-1}

(c) the driver continues to apply the brake for the last 10 seconds

(d) the acceleration a_1 = + 2 ms^{-2} and retardation a_2 = - 4 ms^{-2}

Solution

Correct options: A, B, C. **Method:** Stage 1 (acceleration from rest): $s_1 = (1/2)a_1t^2$, so $100 = (1/2)a_1(10)^2$ and $a_1 = 2\ ms^{-2}$. Then $v = a_1t = 2 \times 10 = 20\ ms^{-1}$. Option (a) is correct. Stage 2 (uniform velocity for 60 s): $s_2 = 20 \times 60 = 1200$ m. Stage 3 (braking over 100 m): $0 = v^2 - 2a_2s_3$, so $a_2 = 20^2/(2 \times 100) = 2\ ms^{-2}$ (retardation, that is, $-2\ ms^{-2}$), not $-4\ ms^{-2}$, so option (d) is incorrect. Time of braking $t_3 = v/a_2 = 20/2 = 10$ s. Option (c) is correct. Average speed $= (100 + 1200 + 100)/(10 + 60 + 10) = 1400/80 = 17.5\ ms^{-1}$. Option (b) is correct.

Answer: (A), (B), (C).

Question 51 (Part A-2, multi correct, 6 marks, all-or-nothing)

On a hot and dry summer day, a person standing between two vertical hills (considered plane and parallel), fires a gun. He hears first echo after 1.5 second of firing the gun and second echo after 1.0 second of hearing the first echo. Considering the speed of sound in air on that hot day to be 360 ms^{-1}, the person will

(a) hear the third echo after 1.5 second of hearing the second echo

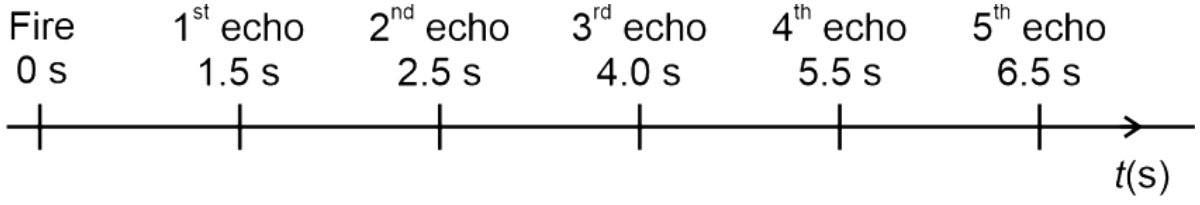
(b) hear the third echo after 4.0 second of hearing the first echo

(c) hear the fourth echo after 5.5 second of firing the gun

(d) find the distance between the two hills to be 720 meter

Solution

Correct options: A, C, D. **Method:** Let d_1 and d_2 be the distances of the person from the nearer and the farther hill. First echo (nearer hill): $2d_1 = 360 \times 1.5$, so $d_1 = 270$ m. Second echo (farther hill) at $t = 1.5 + 1.0 = 2.5$ s: $2d_2 = 360 \times 2.5$, so $d_2 = 450$ m. Distance between the hills $= d_1 + d_2 = 720$ m. Option (d) is correct. Subsequent echoes: the pulse returning from one hill passes the person and is reflected by the other hill. Third echo: path $2d_1 + 2d_2 = 1440$ m, so $t = 1440/360 = 4.0$ s (both pulses arrive together). This is $4.0 - 2.5 = 1.5$ s after the second echo (option (a) correct) and $4.0 - 1.5 = 2.5$ s after the first echo (option (b) incorrect). Fourth echo: path $4d_1 + 2d_2 = 1080 + 900 = 1980$ m, so $t = 1980/360 = 5.5$ s after firing. Option (c) is correct. (The next echo, path $2d_1 + 4d_2 = 2340$ m, arrives at 6.5 s.)



Echo timeline: fire at 0 s, echoes at 1.5 s, 2.5 s, 4.0 s, 5.5 s and 6.5 s.

Answer: (A), (C), (D).

Question 52 (Part A-2, multi correct, 6 marks, all-or-nothing)

As part of its mission to reduce air pollution and promote sustainable transportation in a smart city, the authorities have introduced a fleet of electric buses. At the central bus depot, a high-capacity fast-charging station supplies electricity to the buses between trips. For charging, an electric bus is connected to a charging point that operates at a potential difference of 600 volt and delivers a current of 50 ampere. The bus remains connected to the charger for 45 minutes before resuming service. Based on this information, we can predict that the

(a) electrical power supplied by the charging station to the bus is 30 kilo-watt.

(b) total electrical energy transferred to the bus battery during the charging period is 81 mega joule.

(c) cost incurred for one charging session at 9 rupees per kWh (per unit) is 202.50 rupees

(d) charge flowing through the charging cable during charging is 1×10^6 coulombs.

Solution

Correct options: A, B, C. **Method:** V = 600 V, I = 50 A, t = 45 min = 2700 s = 0.75 h. (a) Power P = VI = 600 × 50 = 30000 W = 30 kW. Correct. (b) Energy E = Pt = 30000 × 2700 = 8.1×10^7 J = 81 MJ. Correct (assuming the whole energy delivered is transferred to the battery). (c) Energy in kWh = 30 kW × 0.75 h = 22.5 kWh; cost = 22.5 × 9 = 202.50 rupees. Correct. (d) Charge Q = It = 50 × 2700 = 1.35×10^5 C, not 1×10^6 C. Incorrect.

Answer: (A), (B), (C).

Question 53 (Part A-2, multi correct, 6 marks, all-or-nothing)

Which of the following is/are the correct statement(s) related with the function of cellular organelles: (a) In hepatocytes residual glycogen has been found with the endoplasmic reticulum of fasted animals. (b) Conversion of fatty acids to Acyl Coenzyme A esters occurs mainly in mitochondria. (c) Glycoprotein is sulphated in the Golgi complex to form Mucigen. (d) Protein synthesis takes place exclusively on isolated individual ribosomes.

(a) In hepatocytes residual glycogen has been found with the endoplasmic reticulum of fasted animals.

(b) Conversion of fatty acids to Acyl Coenzyme A esters occurs mainly in mitochondria.

(c) Glycoprotein is sulphated in the Golgi complex to form Mucigen.

(d) Protein synthesis takes place exclusively on isolated individual ribosomes.

Solution

Correct options: A, C. **Method:** Statements (b) and (d) are incorrect. The activation/conversion of fatty acids into fatty acyl-CoA esters by acyl-CoA synthetase occurs primarily in the cytosol (specifically on the outer mitochondrial membrane and endoplasmic reticulum), before the acyl group is transported into the mitochondrial matrix via the carnitine shuttle for beta-oxidation. Active protein synthesis (translation) typically occurs on polyribosomes (polysomes), clusters of multiple ribosomes simultaneously translating a single mRNA strand, rather than exclusively on isolated individual ribosomes. Statements (a) and (c) are correct: residual glycogen is found associated with the endoplasmic reticulum in hepatocytes of fasted animals, and glycoproteins are sulphated in the Golgi complex to form mucigen.

Answer: (A), (C).

Question 54 (Part A-2, multi correct, 6 marks, all-or-nothing)

Following are the statements regarding important Biosphere Reserves of India. Choose the option(s) which do/ does not correlate with their characteristic geography: (a) Norek Biosphere Reserve covers parts of Garo Hill districts. (b) Simlipal Biosphere Reserve is the largest contiguous mangrove area in the world. (c) Satpura National Park comes under Panchmarhi Biosphere Reserve. (d) Khangchendzonga Biosphere Reserve extends along the Himalayan forest hills to the south of Brahmaputra valley.

(a) Norek Biosphere Reserve covers parts of Garo Hill districts.

(b) Simlipal Biosphere Reserve is the largest contiguous mangrove area in the world.

(c) Satpura National Park comes under Panchmarhi Biosphere Reserve.

(d) Khangchendzonga Biosphere Reserve extends along the Himalayan forest hills to the south of Brahmaputra valley.

Solution

Correct options: B, D. **Method:** The question asks for the statements that do NOT correlate with the geography. (a) Nokrek Biosphere Reserve is located in the Garo Hills district of Meghalaya, so it correlates. (b) Simlipal Biosphere Reserve (in Odisha) is known for tropical moist deciduous/sal forests and tigers, not mangroves; the Sundarbans is the largest contiguous mangrove forest in the world, so (b) does not correlate. (c) Satpura National Park forms part of the Pachmarhi Biosphere Reserve in Madhya Pradesh, so it correlates. (d) Khangchendzonga Biosphere Reserve is situated in Sikkim in the Eastern Himalayas (north/northwest of the Brahmaputra basin), whereas the hills lying to the south of the Brahmaputra valley belong to the Meghalaya Plateau and Purvanchal range, so (d) does not correlate.

Answer: (B), (D).

Question 55 (Part A-2, multi correct, 6 marks, all-or-nothing)

Which of the following Phyla of algae have reserve food material as starch?

(a) Phaeophyta (b) Pyrrophyta (c) Chlorophyta (d) Rhodophyta

Solution

Correct options: B, C, D. **Method:** Stored reserve food: Phaeophyta (brown algae) store laminarin and mannitol; Pyrrophyta (dinoflagellates) store starch-like alpha-1,4 glucans; Chlorophyta (green algae) store starch; Rhodophyta (red algae) store floridean starch. So the phyla with starch (or starch-like) reserve food are Pyrrophyta, Chlorophyta and Rhodophyta.

Answer: (B), (C), (D).

Question 56 (Part A-2, multi correct, 6 marks, all-or-nothing)

Which of the following statements regarding Genetic Drift is/are correct?

(a) It is a non-directional process that leads to changes in allele frequencies due to random sampling error.

(b) Its effects are most pronounced and significant in large, panmictic populations.

(c) It can result in the complete loss of an allele or the fixation of another, regardless of whether the allele is beneficial or harmful.

(d) The founder effect and population bottleneck are specific scenarios where genetic drift is intensified.

Solution

Correct options: A, C, D. **Method:** (a) Correct: genetic drift is a random, non-directional process that alters allele frequencies across generations due to random sampling error. (b) Incorrect: genetic drift is strongest in small populations; in large, panmictic (randomly mating) populations, random sampling fluctuations are negligible. (c) Correct: over time, random fluctuations can drive an allele to fixation (frequency = 1) or complete loss (frequency = 0), regardless of whether the allele is beneficial, neutral or harmful. (d) Correct: both the founder effect and population bottlenecks sharply reduce effective population size, which intensifies genetic drift.

Answer: (A), (C), (D).

Question 57 (Part A-2, multi correct, 6 marks, all-or-nothing)

100 mL of 0.2 M HCl is mixed with 100 mL of 0.1 M NaOH and 100 mL of 0.1 M CH_3COOH (dissociation constant Ka = 1.8×10^{-5}). Which statements are correct?

(a) The final mixture contains excess HCl and CH_3COOH after neutralization

(b) The pH of the resulting solution is less than 3

(c) The resulting solution is a buffer solution

(d) Moles of H+ from HCl alone exceed total moles of OH- available

Solution

Correct options: A, B, D. **Method:** Moles: HCl = 0.1 L × 0.2 = 0.02 mol; NaOH = 0.1 × 0.1 = 0.01 mol; CH_3COOH = 0.1 × 0.1 = 0.01 mol. NaOH neutralises the strong acid first: HCl + NaOH gives NaCl + H_2O. HCl left = 0.02 - 0.01 = 0.01 mol; CH_3COOH (0.01 mol) remains unreacted. (d) Moles of H+ from HCl (0.02) are more than moles of OH- (0.01). (b) Total volume = 300 mL; [H+] from excess HCl = 0.01/0.3 = 0.0333 M (dissociation of CH_3COOH is suppressed by the common ion H+ and is negligible). pH = -log(0.0333), about 1.48, which is less than 3. (a) is correct: excess HCl and CH_3COOH are both present. (c) is incorrect: no CH_3COO^- (conjugate base) is present and a strong acid is in excess, so the solution is not a buffer.

Answer: (A), (B), (D).

Question 58 (Part A-2, multi correct, 6 marks, all-or-nothing)

5.6 g of CO and 6.4 g of O_2 are taken in a closed container. After the reaction $2CO + O_2$ gives $2CO_2$ goes to completion, which statements are correct? (Molar masses: C = 12, O = 16)

(a) CO is the limiting reagent

(b) 0.1 mol of O_2 remains unreacted

(c) The mole fraction of CO_2 in the final mixture is $\frac{2}{3}$

(d) The total moles of gas in the container decreases by 0.1 mol compared to initial

Solution

Correct options: A, B, C, D. **Method:** Moles of CO = 5.6/28 = 0.2 mol; moles of O_2 = 6.4/32 = 0.2 mol. For $2CO + O_2$ gives $2CO_2$, 0.2 mol CO needs only 0.1 mol O_2. So CO is the limiting reagent and 0.2 - 0.1 = 0.1 mol O_2 remains. CO_2 formed = 0.2 mol. Final mixture: CO_2 = 0.2 mol, O_2 = 0.1 mol, total = 0.3 mol. Mole fraction of CO_2 = 0.2/0.3 = 2/3. Initial total moles = 0.4 mol; final = 0.3 mol; decrease = 0.1 mol. All four statements are correct.

Answer: (A), (B), (C), (D).

Question 59 (Part A-2, multi correct, 6 marks, all-or-nothing)

Which of the following are isoelectronic and isostructural?

(a) NO_3^- (b) CO_3^{2-} (c) ClO_3^- (d) SO_3

Solution

Correct options: A, B. **Method:** Total electrons: NO_3^- = 7 + 24 + 1 = 32; CO_3^{2-} = 6 + 24 + 2 = 32; ClO_3^- = 17 + 24 + 1 = 42; SO_3 = 16 + 24 = 40. Shapes: NO_3^- is sp^2, trigonal planar; CO_3^{2-} is sp^2, trigonal planar; ClO_3^- is sp^3 with one lone pair, trigonal pyramidal; SO_3 is sp^2, trigonal planar. NO_3^- and CO_3^{2-} are both isoelectronic (32 electrons) and isostructural (trigonal planar). SO_3 is trigonal planar but not isoelectronic with them.

Answer: (A), (B).

Question 60 (Part A-2, multi correct, 6 marks, all-or-nothing)

Select the correct statement(s): (a) An electron near the nucleus is attracted by the nucleus and has a low potential energy. (b) According to Bohr's theory, electrons continuously radiate energy if it stays in one orbit. (c) Bohr's model could not explain the spectra of multi-electron atoms. (d) Bohr's model was the first atomic model based on quantisation of energy.

(a) An electron near the nucleus is attracted by the nucleus and has a low potential energy.

(b) According to Bohr's theory, electrons continuously radiate energy if it stays in one orbit.

(c) Bohr's model could not explain the spectra of multi-electron atoms.

(d) Bohr's model was the first atomic model based on quantisation of energy.

Solution

Correct options: A, C, D. **Method:** (a) The potential energy of the electron, $U = -kZe^2/r$, becomes more negative (lower) as r decreases, that is, as the electron comes closer to the nucleus. Correct. (b) Bohr postulated that an electron revolving in a stationary orbit does not radiate energy; energy is emitted or absorbed only when it jumps from one orbit to another. So (b) is incorrect. (c) Bohr's model explains the spectra of hydrogen and hydrogen-like species (He^+, Li^{2+}) only; it fails for multi-electron atoms. Correct. (d) Bohr's model (1913) was the first atomic model to incorporate the quantisation of energy (stationary states of definite energy) using Planck's quantum theory. Correct.

Answer: (A), (C), (D).