GATE Ecology and Evolution

Sample Paper – 4

Duration: 128 Minutes **Maximum Marks: 72**

Instructions

- This paper contains **46 questions** covering the core **Ecology and Evolution** subject of the GATE paper conducted by the IITs and IISc (General Aptitude and Engineering Mathematics are provided as separate papers).
- **Q1–Q20 carry 1 mark each** and **Q21–Q46 carry 2 marks each**, for a total of **72 marks**.
- Each question carries **negative marking of one-third of its allotted marks**: a wrong 1-mark question costs **0.33** and a wrong 2-mark question costs **0.67**. Unattempted questions carry no penalty.
- Every question here is a single-correct **MCQ**. The real GATE paper also has Multiple Select (MSQ) and Numerical Answer Type (NAT) questions, and **those carry no negative marking**.
- Attempt this paper in one timed sitting of about **128 minutes**, the share this core subject earns at GATE's overall pace of 180 minutes for 65 questions. Unless stated otherwise, take $\ln 2 = 0.693$ and $\ln 3 = 1.099$, and assume large, randomly mating populations for all Hardy–Weinberg calculations.

Fundamentals of Ecology

Q1. The orderly, predictable sequence of community change that begins on a newly exposed lifeless surface with no pre-existing soil, such as bare rock left by a retreating glacier or a cooled lava flow, is called: **[1 mark]**

(A) secondary succession

(B) eutrophication

(C) primary succession

(D) a climax community

Q2. The first hardy organisms, such as lichens and mosses, that colonize a bare, lifeless substrate at the start of primary succession are collectively called the: **[1 mark]**

(A) climax species

(B) keystone species

(C) pioneer species

(D) invasive species

Q3. The relatively stable, self-perpetuating community that represents the end point of an ecological succession, remaining in equilibrium with the prevailing climate, is the: **[1 mark]**

(A) pioneer stage

(B) seral stage

(C) disturbance patch

(D) climax community

Q4. For an ectothermic animal the metabolic rate has a temperature coefficient $Q_{10} = 3$. If its metabolic rate is 5 units at $15°$C, its rate at $25°$C is: **[1 mark]**

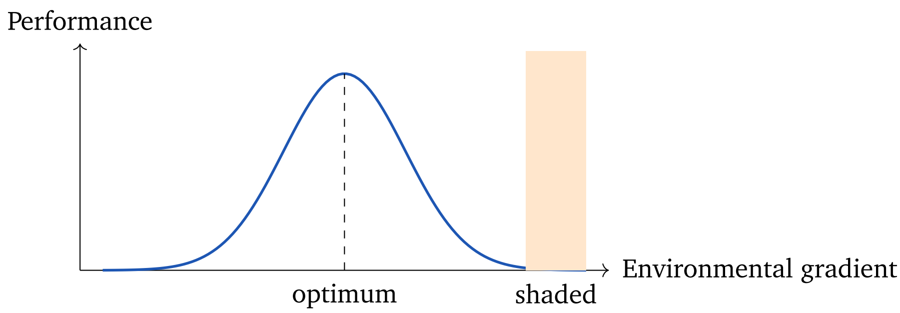
(A) 5 units

(B) 8 units

(C) 15 units

(D) 45 units

Q5. The tolerance curve below plots the performance of a species against an environmental gradient. The shaded region at the far right, beyond which no individuals can survive, is the: **[1 mark]**



(A) optimum range

(B) zone of physiological stress

(C) lower limit of tolerance

(D) zone of intolerance

Q6. An organism that can survive only within a narrow range of environmental temperature is described as: **[1 mark]**

(A) euryhaline

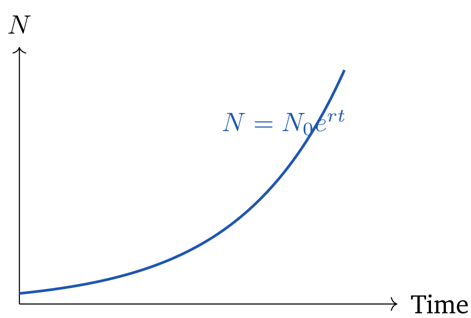
(B) eurythermal

(C) stenohaline

(D) stenothermal

Population and Community Ecology

Q7. A population grows exponentially with a constant per-capita rate $r = 0.0231\ \text{yr}^{-1}$, as sketched below. Using doubling time $t_d = \dfrac{\ln 2}{r}$, the time for the population to double is: **[1 mark]**



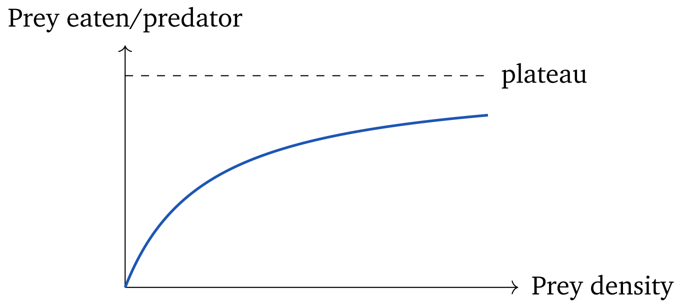
(A) 30 years

(B) 15 years

(C) 60 years

(D) 3 years

Q8. The curve below plots the number of prey eaten per predator against prey density. The intake rises and then levels off at a plateau set by the predator's handling time per prey item. This saturating curve is a: **[1 mark]**



(A) Type I functional response

(B) density-independent response

(C) Type II functional response

(D) Type III functional response

Q9. A population grows logistically with intrinsic rate $r = 0.8$ yr^{-1} and carrying capacity $K = 500$. When the current size is $N = 100$, the instantaneous growth rate $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$ is: **[1 mark]**

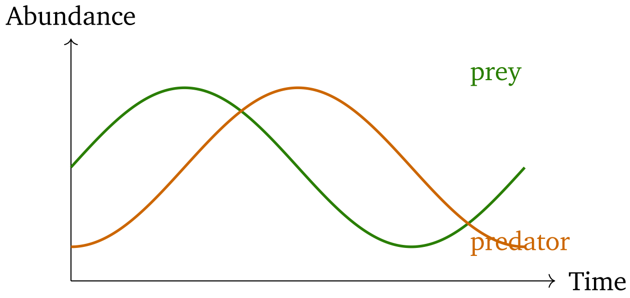
(A) 64 individuals/year

(B) 80 individuals/year

(C) 100 individuals/year

(D) 40 individuals/year

Q10. The two abundance curves below track a predator and its prey over time; the predator peak consistently lags one-quarter of a cycle behind the prey peak. This coupled, out-of-phase oscillation is predicted by the: **[1 mark]**



(A) logistic competition model

(B) Hardy–Weinberg model

(C) Lotka–Volterra predator–prey model

(D) island biogeography model

Q11. On a rocky shore, experimentally removing the predatory sea star *Pisaster* lets mussels monopolize the space and eliminate most other species, collapsing local diversity. *Pisaster* is best described as a: **[1 mark]**

(A) keystone species

(B) pioneer species

(C) primary producer

(D) invasive competitor

Q12. An interspecific interaction in which one species benefits while the other is neither helped nor harmed $(+/0)$, such as a barnacle attached to a whale, is called: **[1 mark]**

(A) mutualism $(+/+)$

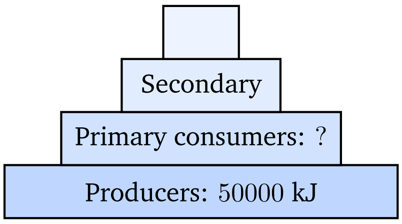
(B) commensalism $(+/0)$

(C) parasitism $(+/-)$

(D) competition $(-/-)$

Ecosystems and Biogeochemical Cycles

Q13. According to Lindeman's ten-percent law of energy transfer, illustrated by the pyramid below, if the producers fix 50000 kJ of energy then the energy available to the primary consumers (herbivores) is approximately: **[1 mark]**



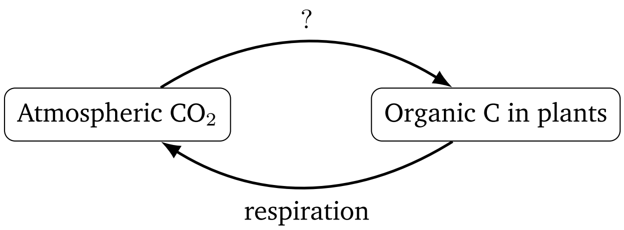
(A) 50000 kJ

(B) 500 kJ

(C) 50 kJ

(D) 5000 kJ

Q14. In the carbon cycle sketched below, the process along the marked arrow, by which atmospheric CO_2 is fixed into organic compounds by green plants, is: **[1 mark]**



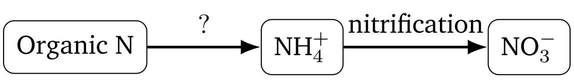
(A) respiration

(B) photosynthesis

(C) combustion

(D) decomposition

Q15. In the nitrogen cycle shown, the microbial conversion of organic nitrogen in dead tissue and animal waste back into ammonium (NH_4^+) is called: **[1 mark]**



(A) nitrification

(B) nitrogen fixation

(C) denitrification

(D) ammonification

Q16. Which one of the following is the single largest reservoir of carbon in the global carbon cycle? **[1 mark]**

(A) the atmosphere

(B) living biomass

(C) recoverable fossil fuels

(D) sedimentary rocks and carbonate deposits

Q17. Which one of the following converts atmospheric N_2 into a biologically usable form within the root nodules of leguminous plants? **[1 mark]**

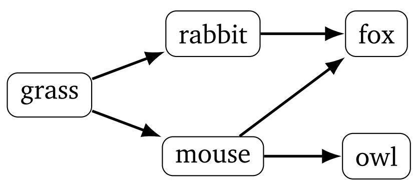
(A) symbiotic *Rhizobium* bacteria

(B) saprophytic decomposer fungi

(C) nitrifying archaea of the open ocean

(D) denitrifying soil bacteria

Q18. In the grassland food web shown, which organism is a primary consumer (herbivore)? **[1 mark]**



(A) fox

(B) rabbit

(C) owl

(D) grass

Mechanisms of Evolution

Q19. Of the three modes of natural selection, directional selection acts to: **[1 mark]**

(A) shift the population mean toward one extreme phenotype

(B) favour the average phenotype and reduce the variance

(C) favour both phenotypic extremes at once

(D) leave allele frequencies unchanged

Q20. The reciprocal evolutionary change in two interacting species, in which a long-spurred orchid and its long-tongued hawkmoth pollinator each drive change in the other's traits, is called: **[1 mark]**

(A) convergent evolution

(B) genetic drift

(C) coevolution

(D) parallel evolution

Q21. In the obligate mutualism between a yucca plant and the yucca moth, the moth actively pollinates the flower while its larvae consume only a fraction of the developing seeds, so each partner depends on the other for reproduction. This reciprocal, benefit-for-benefit dependence is best described as: **[2 marks]**

(A) mutualistic coevolution

(B) commensal drift

(C) Batesian mimicry

(D) competitive exclusion

Q22. A particular genotype has relative fitness $w = 0.65$. The selection coefficient acting against it, defined as $s = 1 - w$, is: **[2 marks]**

(A) 0.35

(B) 0.65

(C) 1.65

(D) 0.50

Q23. As a predator evolves greater speed, its prey evolve better escape responses, which in turn selects for still faster predators, and so on over many generations. This reciprocal escalation between antagonists is best described as: **[2 marks]**

(A) mutualism

(B) genetic drift

(C) antagonistic coevolution (an evolutionary arms race)

(D) stabilizing selection

Q24. In a recipient population the frequency of allele A is 0.7. In one generation a fraction $m = 0.25$ of the individuals are replaced by migrants from a source population in which the frequency of A is 0.3. Using $p' = (1-m)p + m\,p_m$, the new frequency of A is: **[2 marks]**

(A) 0.70

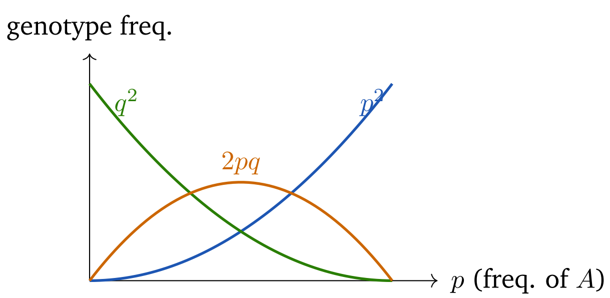
(B) 0.30

(C) 0.45

(D) 0.60

Population and Quantitative Genetics

Q25. In a population at Hardy–Weinberg equilibrium the recessive allele a has frequency $q = 0.2$. From the genotype-frequency curves sketched below, the frequency of heterozygotes (Aa), given by $2pq$, is: **[2 marks]**



(A) 0.16

(B) 0.04

(C) 0.32

(D) 0.64

Q26. A recessive genetic disease affects 1 in 2500 individuals, so that $q^2 = 0.0004$. Assuming Hardy–Weinberg equilibrium, the frequency of carriers (heterozygotes) in the population is approximately: **[2 marks]**

(A) 0.0004

(B) 0.039

(C) 0.98

(D) 0.02

Q27. In quantitative genetics, a quantitative trait locus (QTL) is: **[2 marks]**

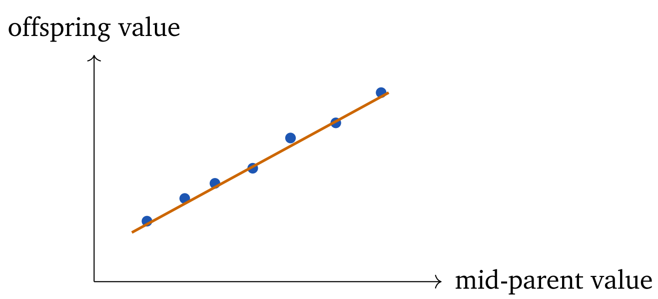
(A) a single gene producing only two discrete, non-overlapping phenotypes

(B) an environmental factor that alters the phenotype without any genetic basis

(C) a region of the genome statistically associated with variation in a quantitative trait

(D) a mutation that is always lethal in the homozygous state

Q28. The scatter of offspring trait values against mid-parent values is plotted below, with the fitted regression line drawn through the cloud. The slope of this line estimates the narrow-sense heritability h^2, which is defined as the ratio of: **[2 marks]**



(A) additive genetic variance to total phenotypic variance

(B) total phenotypic variance to additive genetic variance

(C) environmental variance to total genetic variance

(D) dominance variance to total phenotypic variance

Q29. The breeder's equation predicts the response to selection as $R = h^2S$, where S is the selection differential. If the narrow-sense heritability is $h^2 = 0.4$ and the selection differential is $S = 10$ g, the predicted response R is: **[2 marks]**

(A) 10 g

(B) 4 g

(C) 0.4 g

(D) 6 g

Q30. In a sample of 100 diploid individuals the genotype counts are $AA = 49$, $Aa = 42$ and $aa = 9$. The frequency of allele A in the sample is: **[2 marks]**

(A) 0.70

(B) 0.49

(C) 0.42

(D) 0.30

Speciation, Phylogeny and Macroevolution

Q31. Speciation that occurs within a single geographic area, with no physical barrier separating the diverging groups, for example through instantaneous polyploidy or a shift to a new host plant, is called: **[2 marks]**

(A) allopatric speciation

(B) sympatric speciation

(C) peripatric speciation

(D) vicariance

Q32. Under the phylogenetic species concept, a species is defined as: **[2 marks]**

(A) any set of organisms that happen to live in the same habitat

(B) a group recognised solely by its ability to interbreed

(C) all organisms that share a similar body size

(D) the smallest diagnosable cluster of organisms sharing a common ancestor

Q33. Two closely related frog species live in the same pond but breed in different months of the year, so their gametes never meet. This form of reproductive isolation is best described as: [2 marks]

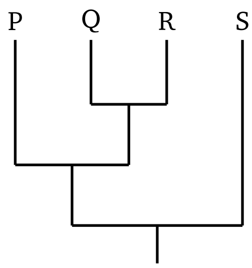
(A) temporal isolation, a prezygotic barrier

(B) hybrid sterility, a postzygotic barrier

(C) hybrid inviability, a postzygotic barrier

(D) mechanical isolation caused by mismatched genitalia

Q34. In the cladogram shown, which two taxa share the most recent common ancestor (are sister taxa)? [2 marks]



(A) P and S

(B) P and Q

(C) Q and R

(D) R and S

Q35. The principle of maximum parsimony in phylogenetic inference selects, from among competing trees, the tree that: [2 marks]

(A) requires the fewest evolutionary character-state changes

(B) contains the largest number of branches

(C) maximizes the number of independently evolved similarities

(D) includes the greatest number of terminal taxa

Q36. A character state shared by two taxa because of convergent evolution rather than inheritance from a common ancestor, such as the streamlined body shape of sharks and dolphins, is called a: **[2 marks]**

(A) synapomorphy

(B) homoplasy

(C) symplesiomorphy

(D) autapomorphy

Behavioural Ecology

Q37. In the optimal diet (prey-choice) model, a forager that encounters a lower-ranked prey type should add it to the diet only if that prey's profitability (energy gained per unit handling time) exceeds: **[2 marks]**

(A) the total energy content of every prey item in the habitat

(B) the average net rate of energy gain from specialising on the higher-ranked prey already accepted

(C) the metabolic cost of thermoregulation while resting

(D) the number of rival foragers present in the patch

Q38. The marginal value theorem predicts that a forager exploiting a depleting food patch should leave the patch at the moment when: **[2 marks]**

(A) its instantaneous intake rate in the patch falls to the average intake rate for the whole habitat

(B) the patch has been completely emptied of all food

(C) it has spent a fixed, pre-set time in the patch regardless of intake

(D) a predator first becomes visible nearby

Q39. Hamilton's rule states that an altruistic act spreads by kin selection when $rB > C$, where r is the coefficient of relatedness between actor and recipient. For half-siblings, which share only one parent, r equals: **[2 marks]**

(A) 0.5

(B) 0.25

(C) 0.125

(D) 1.0

Q40. A predator choosing between two prey types finds that large prey yield 8 units of energy but take 4 s to handle, while small prey yield 3 units of energy and take 1 s to handle. Comparing profitability (energy per unit handling time), which prey type is the more profitable? **[2 marks]**

(A) large prey, at 8 units/s

(B) the two prey types are exactly equal

(C) large prey, at 2 units/s

(D) small prey, at 3 units/s

Q41. The dilution effect, whereby an individual in a large aggregation has a lower per-capita probability of being the one taken by an attacking predator, is a well-known anti-predator benefit of: **[2 marks]**

(A) strict territoriality

(B) solitary foraging

(C) infanticide by dominant males

(D) group (social) living

Quantitative Ecology, Biostatistics and Mathematics

Q42. For the data set $\{3, 5, 7, 9, 11\}$ of counts recorded at five quadrats, the arithmetic mean is: **[2 marks]**

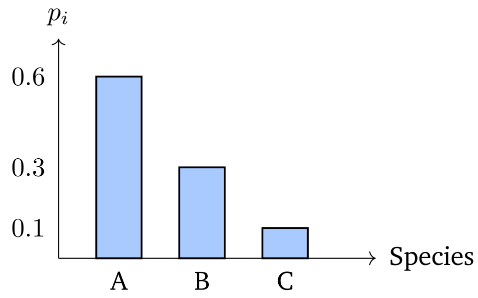
(A) 5

(B) 7

(C) 9

(D) 35

Q43. A community contains three species with proportional abundances $p_1 = 0.6$, $p_2 = 0.3$ and $p_3 = 0.1$, shown in the bar chart. Simpson's index $D = \sum_i p_i^2$ for this community equals: **[2 marks]**



(A) 0.54

(B) 0.46

(C) 1.00

(D) 0.10

Q44. In a one-way analysis of variance (ANOVA) used to compare the mean growth of plants across several fertiliser treatments, the F-statistic is computed as the ratio of: **[2 marks]**

(A) the total variance to the sample size

(B) the within-group mean square to the between-group mean square

(C) the between-group mean square to the within-group mean square

(D) the grand mean to the pooled standard deviation

Q45. A one-way ANOVA compares 4 treatment groups with 6 replicate plots in each group (total $N = 24$). The between-group (treatment) degrees of freedom, $k - 1$, is: **[2 marks]**

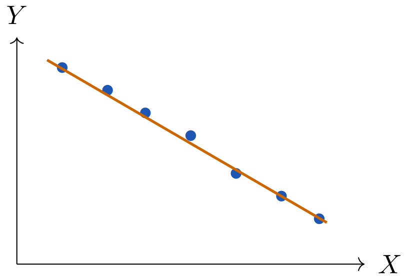
(A) 4

(B) 3

(C) 23

(D) 20

Q46. The scatter plot below shows measurements of two variables X and Y together with a fitted straight line of negative slope through a tight cloud of points. The correlation coefficient r for these data is best described as: **[2 marks]**



(A) positive, with $0 < r < 1$

(B) exactly zero

(C) exactly $+1$

(D) negative, with $-1 < r < 0$

Detailed Solutions

Q1.

Solution

Concept – primary succession: Succession is the gradual replacement of one community by another over time.

Step 1 – read the key detail: The surface is newly exposed and lifeless, with no pre-existing soil.

Step 2 – classify the starting point: Succession that begins where no soil or life was present before is primary succession.

Step 3 – contrast with secondary succession: Secondary succession begins on a disturbed site (such as after a fire) where soil and some organisms already remain.

Step 4 – reject the other options: A climax community is the end point, not the start; eutrophication is nutrient enrichment of water, not a colonisation sequence.

Final Answer: primary succession $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept – pioneer species: The earliest colonists of a bare substrate are tolerant of harsh conditions and begin building soil.

Step 1 – identify the stage: The organisms appear first, at the very start of primary succession.

Step 2 – name them: Lichens and mosses that first invade bare rock are the pioneer species.

Step 3 – reject the others: Climax species dominate the final stage; keystone species have a disproportionate ecological effect; invasive species are introduced non-natives, not defined by successional order.

Final Answer: pioneer species $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept – the climax community: Succession proceeds through a series of transient stages toward a stable end state.

Step 1 – read the requirement: A stable, self-perpetuating community in equilibrium with the climate.

Step 2 – name the end state: That final, self-replacing community is the climax community.

Step 3 – reject the others: Pioneer and seral stages are intermediate and transient; a disturbance patch resets succession rather than completing it.

Final Answer: climax community $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q3

Q4.

Solution

Concept – the temperature coefficient Q_{10}: Q_{10} is the factor by which a rate changes for each $10°$C rise. Here $Q_{10} = 3$ means the rate triples per $10°$C.

Step 1 – find the temperature change: $\Delta T = 25 - 15 = 10°\text{C}$

Step 2 – count the $10°$C steps: $\frac{10}{10} = 1$ step

Step 3 – apply the multiplier once: $\text{rate}_{25} = 5 \times 3^1$

Step 4 – evaluate: $\text{rate}_{25} = 5 \times 3 = 15$ units

Why the other options are wrong: 45 would correspond to two steps ($15°$ to $35°$C); 5 leaves the rate unchanged.

Final Answer: 15 units $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q4

Q5.

Solution

Concept – the tolerance curve: Performance is greatest in a central optimum band and falls to zero beyond the limits of tolerance.

Step 1 – read the figure: The shaded band lies at the far right, past the point where the curve reaches the axis.

Step 2 – name that region: Beyond the upper limit of tolerance no individuals survive; this is the zone of intolerance.

Step 3 – reject the others: The optimum is at the peak, physiological stress lies just inside the limits, and the lower limit is at the opposite (left) tail.

Final Answer: zone of intolerance $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept – prefixes for breadth of tolerance: "Steno-" means narrow and "eury-" means broad; "-thermal" refers to temperature and "-haline" to salinity.

Step 1 – decode the requirement: Narrow range of temperature means narrow + temperature.

Step 2 – assemble the term: narrow (steno) + temperature (thermal) = stenothermal.

Step 3 – reject the others: Eurythermal is broad temperature; the haline terms refer to salinity, not temperature.

Final Answer: stenothermal $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept – doubling time of exponential growth: For $N = N_0 e^{rt}$, the population doubles after a time $t_d = \dfrac{\ln 2}{r}$.

Step 1 – list the data: $r = 0.0231$ yr^{-1} and $\ln 2 = 0.693$.

Step 2 – write the doubling-time formula: $t_d = \dfrac{\ln 2}{r}$

Step 3 – substitute: $t_d = \dfrac{0.693}{0.0231}$

Step 4 – evaluate: $t_d = 30$ years

Final Answer: 30 years $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept – Holling's functional responses: A functional response describes how prey intake per predator changes with prey density. Type I rises linearly; Type II rises and saturates because handling time limits it; Type III is S-shaped.

Step 1 – read the curve: Intake rises steeply at first and then levels off to a flat plateau.

Step 2 – match the shape: A decelerating rise to a plateau, set by handling time, is the hallmark of the Type II response.

Step 3 – reject the others: Type I would be a straight line, and Type III would show a slow (sigmoid) start before rising.

Final Answer: Type II functional response $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q8

Q9.

Solution

Concept – evaluating the logistic rate: Substitute the given values into $\frac{dN}{dt} = rN\left(1 - \frac{N}{K}\right)$.

Step 1 – list the data: $r = 0.8$ yr^{-1}, $N = 100$, $K = 500$.

Step 2 – compute the bracket: $1 - \frac{N}{K} = 1 - \frac{100}{500} = 1 - 0.2 = 0.8$

Step 3 – multiply r and N: $rN = 0.8 \times 100 = 80$

Step 4 – multiply by the bracket: $\frac{dN}{dt} = 80 \times 0.8 = 64$

Final Answer: 64 individuals/year $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept – coupled predator–prey cycles: When predator numbers depend on prey and prey are cropped by predators, both populations oscillate, with the predator cycle lagging behind the prey cycle.

Step 1 – read the figure: Two curves rise and fall periodically, the predator peak trailing the prey peak by a quarter cycle.

Step 2 – name the model: Such lagged, out-of-phase oscillations are the classic output of the Lotka–Volterra predator–prey equations.

Step 3 – reject the others: The logistic competition, Hardy–Weinberg and island-biogeography models do not generate coupled predator–prey cycles.

Final Answer: Lotka–Volterra predator–prey model $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept – keystone species: A keystone species exerts an effect on community structure far larger than its abundance would suggest; removing it triggers large changes.

Step 1 – read the experiment: Removing the sea star lets mussels take over and wipe out most other species.

Step 2 – interpret the outcome: A predator whose removal collapses diversity is holding the community together; that is a keystone role.

Step 3 – reject the others: It is not a pioneer (this is an established community), not a producer (it is a predator), and not simply an invasive competitor.

Final Answer: keystone species $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept – signs of species interactions: Interactions are classified by the effect on each partner: $+$ (benefit), $-$ (harm) or 0 (no effect).

Step 1 – read the requirement: One species benefits ($+$) while the other is unaffected (0).

Step 2 – match the sign pattern: A $+/0$ interaction is commensalism.

Step 3 – reject the others: Mutualism is $+/+$, parasitism is $+/-$, and competition is $-/-$.

Final Answer: commensalism ($+/0$) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept – Lindeman's ten-percent law: Only about 10% of the energy at one trophic level passes to the next.

Step 1 – start with the producers: Energy fixed $= 50000$ kJ.

Step 2 – transfer to the primary consumers: $10\% \times 50000 = 0.10 \times 50000$

Step 3 – evaluate: $= 5000$ kJ

Step 4 – state the result: The herbivores (primary consumers) receive about 5000 kJ.

Why the other options are wrong: 500 kJ is the next step (secondary consumers); 50000 kJ is the producer level itself.

Final Answer: 5000 kJ $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q13

Q14.

Solution

Concept – carbon fixation: In the carbon cycle, atmospheric CO_2 enters the living world when plants convert it into organic molecules.

Step 1 – read the marked arrow: It runs from atmospheric CO_2 into organic carbon in plants.

Step 2 – name the process: Fixation of CO_2 into sugars by green plants is photosynthesis.

Step 3 – reject the others: Respiration and combustion release CO_2 back to the atmosphere (the opposite direction), and decomposition acts on dead matter, not on atmospheric CO_2.

Final Answer: photosynthesis $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept – steps of the nitrogen cycle: Ammonification releases NH_4^+ from dead organic matter; nitrification oxidises NH_4^+ to NO_3^-; fixation makes NH_4^+ from N_2; denitrification returns NO_3^- to N_2.

Step 1 – read the marked arrow: It runs from organic N to NH_4^+.

Step 2 – match the process: Decomposers converting organic nitrogen into ammonium carry out ammonification.

Step 3 – reject the others: Nitrification makes nitrate, fixation starts from N_2, and denitrification destroys nitrate.

Final Answer: ammonification $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept – carbon reservoirs: Carbon is distributed among the atmosphere, biomass, fossil fuels, oceans, soils and rocks; these reservoirs differ enormously in size.

Step 1 – rank the reservoirs: By far the greatest mass of carbon is locked in sedimentary rocks such as limestone and other carbonate deposits.

Step 2 – compare with the rest: The atmosphere, living biomass and fossil fuels together hold only a tiny fraction of this rock-bound carbon.

Step 3 – conclude: The largest single reservoir is the sedimentary rock and carbonate pool.

Final Answer: sedimentary rocks and carbonate deposits $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept – biological nitrogen fixation in legumes: Some bacteria possess nitrogenase and can reduce atmospheric N_2 to ammonia, which the plant then uses.

Step 1 – read the requirement: N_2 is fixed inside the root nodules of legumes.

Step 2 – name the organism: The symbiotic bacterium living in legume root nodules is *Rhizobium*.

Step 3 – reject the others: Decomposer fungi mineralise organic matter but do not fix N_2; open-ocean nitrifiers oxidise ammonium; denitrifiers convert nitrate back to N_2.

Final Answer: symbiotic *Rhizobium* bacteria $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept – trophic roles in a food web: Producers make their own food; primary consumers (herbivores) eat producers; secondary consumers eat the herbivores.

Step 1 – read the web: Grass is eaten by the rabbit and the mouse; the fox and owl in turn eat those.

Step 2 – identify the herbivore among the options: The rabbit feeds directly on grass, so it is a primary consumer.

Step 3 – reject the others: Grass is the producer; the fox and owl are secondary consumers that eat the herbivores.

Final Answer: rabbit $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept – directional selection: Directional selection favours phenotypes at one end of the distribution, so the population mean moves toward that extreme.

Step 1 – picture the fitness function: Fitness increases steadily from one extreme of the trait to the other.

Step 2 – describe the effect: The mean phenotype shifts in the favoured direction over the generations.

Step 3 – contrast the other modes: Stabilizing selection favours the mean and narrows variance; disruptive selection favours both extremes; and selection that changes nothing is not selection at all.

Final Answer: shifts the population mean toward one extreme phenotype $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q19

Q20.

Solution

Concept – coevolution: When two species act as agents of selection on each other, each evolves in response to the other; this reciprocal change is coevolution.

Step 1 – read the scenario: The orchid's spur and the moth's tongue each drive change in the other.

Step 2 – name the process: Reciprocal, mutually driven evolution of interacting species is coevolution.

Step 3 – reject the others: Convergent and parallel evolution involve unrelated (or related) lineages evolving similar traits independently, not reciprocally; drift is random change unrelated to interaction.

Final Answer: coevolution $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q20

Q21.

Solution

Concept – mutualistic coevolution: In an obligate mutualism each partner both benefits and depends on the other, and over time each shapes the other's traits.

Step 1 – read the interaction: The moth pollinates the yucca (benefit to plant) and its larvae eat some seeds, while the moth gains a nursery (benefit to moth); each partner cannot reproduce without the other.

Step 2 – classify it: A benefit-for-benefit interaction with reciprocal evolutionary tuning is mutualistic coevolution.

Step 3 – reject the others: It is not commensal (both benefit), not Batesian mimicry (no mimic–model deception), and not competitive exclusion (they do not compete for one resource).

Final Answer: mutualistic coevolution $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept – selection coefficient: The selection coefficient measures how far a genotype's fitness falls below the maximum of 1: $s = 1 - w$.

Step 1 – list the data: $w = 0.65$.

Step 2 – substitute into the definition: $s = 1 - 0.65$

Step 3 – evaluate: $s = 0.35$

Final Answer: $s = 0.35 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

Q23.

Solution

Concept – antagonistic coevolution (arms race): When enemies impose selection on each other, an improvement in one triggers a counter-improvement in the other, escalating reciprocally.

Step 1 – read the scenario: Faster predators select for better prey escape, which selects for still faster predators.

Step 2 – name the pattern: This reciprocal escalation between antagonists is an evolutionary arms race, a form of antagonistic coevolution.

Step 3 – reject the others: It is not mutualism (the interaction harms one party), not drift (it is selection-driven), and not stabilizing selection (traits keep escalating rather than settling at a mean).

Final Answer: antagonistic coevolution (an arms race) $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept – change in allele frequency due to gene flow: After migration the new frequency is the weighted average $p' = (1 - m)p + m\,p_m$.

Step 1 – list the data: $p = 0.7$, $m = 0.25$, $p_m = 0.3$.

Step 2 – weight the resident frequency: $(1 - m)p = 0.75 \times 0.7 = 0.525$

Step 3 – weight the migrant frequency: $m\,p_m = 0.25 \times 0.3 = 0.075$

Step 4 – add the two contributions: $p' = 0.525 + 0.075 = 0.60$

Final Answer: $p' = 0.60 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept – Hardy–Weinberg genotype frequencies: With allele frequencies p and q (where $p + q = 1$), the heterozygote frequency is $2pq$.

Step 1 – list the data: $q = 0.2$, so $p = 1 - 0.2 = 0.8$.

Step 2 – write the heterozygote formula: $\text{freq}(Aa) = 2pq$

Step 3 – substitute: $2pq = 2 \times 0.8 \times 0.2$

Step 4 – evaluate: $= 0.32$

Why the other options are wrong: 0.64 is p^2, 0.04 is q^2, and 0.16 is $2 \times 0.2 \times 0.4$, an incorrect pairing.

Final Answer: $2pq = 0.32 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q25

Q26.

Solution

Concept – carrier frequency from disease incidence: The affected are the recessive homozygotes with frequency q^2; carriers are heterozygotes with frequency $2pq$.

Step 1 – find q: $q^2 = 0.0004$, so $q = \sqrt{0.0004} = 0.02$.

Step 2 – find p: $p = 1 - q = 1 - 0.02 = 0.98$.

Step 3 – compute the carrier frequency: $2pq = 2 \times 0.98 \times 0.02$

Step 4 – evaluate: $= 0.0392 \approx 0.039$

Final Answer: carrier frequency $\approx 0.039 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept – quantitative trait locus (QTL): Continuous traits are shaped by many genes; a QTL is a stretch of the genome whose genetic variation is statistically linked to variation in such a trait.

Step 1 – recall how QTLs are found: Marker–trait association mapping locates genome regions where genotype correlates with the value of a quantitative trait.

Step 2 – state the definition: A QTL is a chromosomal region associated with variation in a quantitative (continuous) trait.

Step 3 – reject the others: A QTL is not a single two-phenotype gene, not an environmental factor, and not necessarily a lethal mutation.

Final Answer: a genome region associated with variation in a quantitative trait $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept – narrow-sense heritability: Narrow-sense heritability h^2 is the fraction of the phenotypic variance due to *additive* genetic effects, the part that parents reliably pass on.

Step 1 – read the plot: The offspring-on-midparent regression has a positive slope, and that slope estimates h^2.

Step 2 – state the definition: $h^2 = \frac{V_A}{V_P}$, the additive genetic variance over the total phenotypic variance.

Step 3 – reject the others: Inverting the ratio, or using environmental or dominance variance in the numerator, does not give narrow-sense heritability.

Final Answer: additive genetic variance to total phenotypic variance $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept – the breeder's equation: The response to selection is $R = h^2S$, where S is the selection differential and h^2 is the narrow-sense heritability.

Step 1 – list the data: $h^2 = 0.4$, $S = 10$ g.

Step 2 – substitute: $R = 0.4 \times 10$

Step 3 – evaluate: $R = 4$ g

Final Answer: $R = 4$ g $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q29

Q30.

Solution

Concept – allele frequency from genotype counts: Each AA individual carries two A alleles and each Aa carries one; divide the total A alleles by the total alleles $(2N)$.

Step 1 – list the counts: $AA = 49$, $Aa = 42$, $aa = 9$, so $N = 100$ and $2N = 200$ alleles.

Step 2 – count the A alleles: $2 \times 49 + 1 \times 42 = 98 + 42 = 140$

Step 3 – divide by the total alleles: $\text{freq}(A) = \dfrac{140}{200}$

Step 4 – evaluate: $= 0.70$

Final Answer: $\text{freq}(A) = 0.70 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q30

Q31.

Solution

Concept – sympatric speciation: Sympatric speciation produces new species without any geographic separation of the diverging groups.

Step 1 – read the key detail: There is no physical barrier; divergence happens in one area, for example by polyploidy or a host shift.

Step 2 – classify it: Speciation in the same location, with ongoing potential contact, is sympatric speciation.

Step 3 – reject the others: Allopatric and peripatric speciation both require geographic separation, and vicariance is the splitting of a range by a barrier.

Final Answer: sympatric speciation $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q31

Q32.

Solution

Concept – the phylogenetic species concept: This concept defines species by shared ancestry rather than by interbreeding, identifying the smallest group that can be diagnosed as a distinct lineage.

Step 1 – recall the criterion: A species is the smallest cluster of organisms that is diagnosably distinct and shares a common ancestry.

Step 2 – match the option: That is the smallest diagnosable cluster sharing a common ancestor.

Step 3 – reject the others: Shared habitat or body size is not a phylogenetic criterion, and defining species purely by interbreeding is the biological species concept, not the phylogenetic one.

Final Answer: the smallest diagnosable cluster sharing a common ancestor $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q32

Q33.

Solution

Concept – prezygotic versus postzygotic barriers: Prezygotic barriers act before a zygote forms; postzygotic barriers act afterward. Temporal isolation (breeding at different times) prevents mating and is therefore prezygotic.

Step 1 – read the scenario: The two species breed in different months, so their gametes never meet.

Step 2 – classify the barrier: A difference in breeding time is temporal isolation, which prevents fertilisation and is a prezygotic barrier.

Step 3 – reject the others: Hybrid sterility and hybrid inviability act after a hybrid zygote forms (postzygotic); mechanical isolation involves incompatible reproductive structures, not timing.

Final Answer: temporal isolation, a prezygotic barrier $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q33

Q34.

Solution

Concept – reading a cladogram: Two taxa are most closely related when they join at the most recent (highest) branch point on the tree.

Step 1 – trace the branches: Q and R join each other first, at the topmost internal node.

Step 2 – identify the sister pair: Because Q and R meet at the most recent common node, they are sister taxa.

Step 3 – reject the others: P joins the Q–R clade one node lower, and S branches off at the deepest node, so pairs involving P or S share only older ancestors.

Final Answer: Q and R $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q34

Q35.

Solution

Concept – maximum parsimony: Parsimony chooses the phylogenetic hypothesis that explains the data with the least amount of evolutionary change.

Step 1 – state the criterion: Among candidate trees, prefer the one needing the fewest character-state changes (the shortest tree).

Step 2 – apply it: Minimising changes minimises the number of assumed independent evolutionary events.

Step 3 – reject the others: Parsimony does not seek the most branches, the most homoplasy, or the most taxa; it minimises total change.

Final Answer: the tree requiring the fewest evolutionary changes $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q35

Q36.

Solution

Concept – homoplasy: A homoplasy is a similarity that arose independently (by convergence, parallelism or reversal) rather than by inheritance from a shared ancestor.

Step 1 – read the example: Sharks and dolphins share a streamlined shape, but from different ancestries.

Step 2 – classify the similarity: An independently evolved resemblance is a homoplasy.

Step 3 – reject the others: A synapomorphy is a shared derived character from a common ancestor; a symplesiomorphy is a shared ancestral character; an autapomorphy is unique to one taxon.

Final Answer: homoplasy $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q36

Q37.

Solution

Concept – the optimal diet (prey-choice) model: A forager should specialise on high-profitability prey and add a lower-ranked prey only when doing so raises the overall intake rate.

Step 1 – state the decision rule: Accept the lower-ranked prey only if its profitability exceeds the average rate obtained by continuing to search for and eat the higher-ranked prey.

Step 2 – interpret: If the search-and-handle payoff of the good prey already beats the poor prey's profitability, the poor prey is not worth taking.

Step 3 – reject the others: The threshold is set by the higher-ranked diet's intake rate, not by total habitat energy, thermoregulation costs, or competitor numbers.

Final Answer: the average net rate from the higher-ranked prey already accepted $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q37

Q38.

Solution

Concept – the marginal value theorem: As a forager depletes a patch, its intake rate falls. It should stay until the marginal intake rate in the patch drops to the average rate available in the habitat, then move on.

Step 1 – state the rule: Leave when the instantaneous (marginal) intake rate in the patch equals the habitat-wide average rate.

Step 2 – reason why: Staying longer would earn less than the average, so switching patches pays.

Step 3 – reject the others: The optimum is not to empty the patch, not to use a fixed time, and not tied to predator appearance in this model.

Final Answer: when patch intake rate falls to the habitat average $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q38

Q39.

Solution

Concept – coefficient of relatedness: r is the probability that a gene in one individual is shared identical-by-descent with another. Full siblings share $r = 0.5$; half-siblings, sharing only one parent, share half of that.

Step 1 – recall the full-sibling value: Full siblings have $r = 0.5$.

Step 2 – adjust for one shared parent: Half-siblings share genes through only one parent, so $r = \frac{1}{2} \times 0.5$.

Step 3 – evaluate: $r = 0.25$

Final Answer: $r = 0.25 \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q39

Q40.

Solution

Concept – prey profitability: Profitability is the energy gained per unit handling time, E/h. The forager prefers the prey with the higher E/h.

Step 1 – compute for large prey: $\frac{E}{h} = \frac{8}{4} = 2$ units/s

Step 2 – compute for small prey: $\frac{E}{h} = \frac{3}{1} = 3$ units/s

Step 3 – compare: $3 > 2$, so the small prey is more profitable per second of handling.

Step 4 – state the result: The small prey, at 3 units/s, is the more profitable type.

Final Answer: small prey, at 3 units/s $\Rightarrow \boxed{D}$

Answer: (D) Go Back to Q40

Q41.

Solution

Concept – the dilution effect: In a group of n prey, a single attack that takes one victim gives each member roughly a $1/n$ chance of being taken, so per-capita predation risk falls as group size rises.

Step 1 – read the description: Being one of many lowers an individual's personal chance of being the one caught.

Step 2 – assign the benefit: Spreading risk across many individuals is a benefit of group (social) living.

Step 3 – reject the others: Territoriality and solitary foraging keep individuals apart, and infanticide is not an anti-predator benefit.

Final Answer: group (social) living $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q41

Q42.

Solution

Concept – the arithmetic mean: The mean is the sum of the values divided by the number of values.

Step 1 – add the values: $3 + 5 + 7 + 9 + 11 = 35$

Step 2 – count the values: There are 5 quadrat counts.

Step 3 – divide: $\bar{x} = \dfrac{35}{5}$

Step 4 – evaluate: $= 7$

Final Answer: mean $= 7 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q42

Q43.

Solution

Concept – Simpson's index: The concentration form of Simpson's index is $D = \sum_i p_i^2$, the probability that two randomly drawn individuals belong to the same species.

Step 1 – list the proportions: $p_1 = 0.6$, $p_2 = 0.3$, $p_3 = 0.1$.

Step 2 – square each proportion: $0.6^2 = 0.36; \quad 0.3^2 = 0.09; \quad 0.1^2 = 0.01$

Step 3 – sum the squares: $D = 0.36 + 0.09 + 0.01$

Step 4 – evaluate: $D = 0.46$

Final Answer: $D = 0.46 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q43

Q44.

Solution

Concept – the F-statistic in one-way ANOVA: ANOVA partitions total variation into a between-group part (differences among treatment means) and a within-group part (variation among replicates). The test statistic compares these.

Step 1 – recall the ratio: $F = \dfrac{\text{between-group mean square }(\text{MS}_{\text{treatment}})}{\text{within-group mean square }(\text{MS}_{\text{error}})}$

Step 2 – interpret it: A large F means the differences among treatment means are large relative to the noise within groups.

Step 3 – reject the others: Inverting the ratio, dividing variance by sample size, or comparing the mean to the standard deviation does not give F.

Final Answer: between-group mean square to within-group mean square $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q44

Q45.

Solution

Concept – degrees of freedom in one-way ANOVA: With k groups and N total observations, the between-group df is $k-1$, the within-group df is $N-k$, and the total df is $N-1$.

Step 1 – list the design: $k = 4$ treatment groups, $N = 24$ observations.

Step 2 – apply the between-group formula: $\text{df}_{\text{between}} = k - 1$

Step 3 – substitute and evaluate: $= 4 - 1 = 3$

Why the other options are wrong: $N-k = 20$ is the within-group df and $N-1 = 23$ is the total df; 4 is the number of groups, not the df.

Final Answer: $\text{df}_{\text{between}} = 3 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q45

Q46.

Solution

Concept – sign of the correlation coefficient: The correlation coefficient r lies between -1 and $+1$; its sign follows the slope of the trend and its magnitude measures how tightly the points hug the line.

Step 1 – read the scatter: Y falls steadily as X rises, and the points lie close to the fitted line.

Step 2 – fix the sign: A downward trend gives a negative r.

Step 3 – fix the magnitude: The scatter is close to, but not exactly on, the line, so $-1 < r < 0$.

Final Answer: negative, with $-1 < r < 0 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q46

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	C	3	D	4	C	5	D
6	D	7	A	8	C	9	A	10	C
11	A	12	B	13	D	14	B	15	D
16	D	17	A	18	B	19	A	20	C
21	A	22	A	23	C	24	D	25	C
26	B	27	C	28	A	29	B	30	A
31	B	32	D	33	A	34	C	35	A
36	B	37	B	38	A	39	B	40	D
41	D	42	B	43	B	44	C	45	B
46	D								