# GATE Ecology and Evolution

## Sample Paper – 2

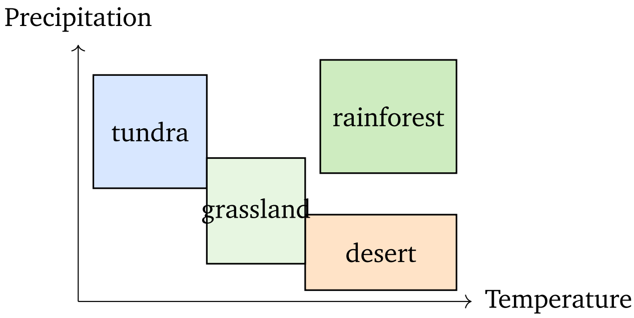
**Duration: 128 Minutes** **Maximum Marks: 72**

### 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 assume large, randomly mating populations for all Hardy–Weinberg calculations.

## Fundamentals of Ecology

**Q1.** In Whittaker's classification of the world's terrestrial biomes, shown schematically below, the position of each biome is fixed principally by two climatic variables. These two variables are: [1 mark]




(A) soil pH and altitude

(B) day length and wind speed

(C) latitude and longitude

(D) mean annual temperature and mean annual precipitation

**Q2.** A terrestrial biome that receives less than about 25 cm of rainfall a year and is dominated by sparse, water-conserving vegetation is the: **[1 mark]**

(A) tropical rainforest

(B) temperate grassland

(C) tundra

(D) desert

**Q3.** The biome found at very high latitudes near the poles, marked by permanently frozen subsoil (permafrost), extremely low temperatures and a very short growing season, is the: **[1 mark]**

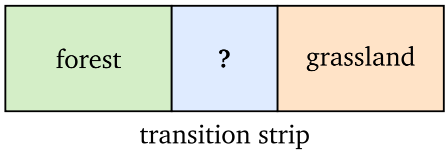
(A) savanna

(B) chaparral

(C) tundra

(D) tropical deciduous forest

**Q4.** The narrow transition zone between two adjacent communities or biomes, such as the strip between a forest and a grassland shown below, which often supports species from both sides plus edge specialists, is called a(n): **[1 mark]**



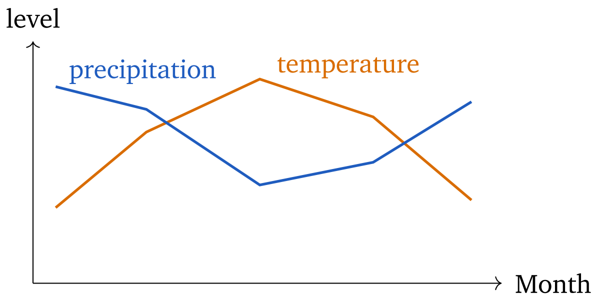

(A) biome

(B) niche

(C) ecotone

(D) ecocline

**Q5.** In the Walter-style climate diagram below the monthly temperature and precipitation curves are overlaid. An arid (drought) period is identified as those months in which: **[1 mark]**




(A) precipitation exceeds twice the temperature

(B) the precipitation curve falls below the temperature curve

(C) the temperature is below freezing

(D) rainfall is at its annual maximum

**Q6.** Within a warm-blooded species, populations living in colder regions tend to have a larger average body size than populations of warmer regions. This ecogeographic generalization is known as: **[1 mark]**

(A) Allen's rule

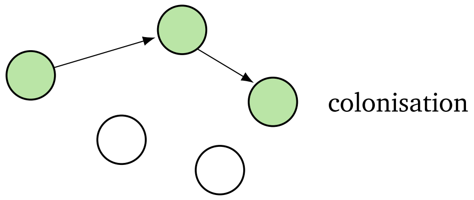
(B) Gloger's rule

(C) Cope's rule

(D) Bergmann's rule

## Population and Community Ecology

**Q7.** In Levins' classic metapopulation model $\frac{dp}{dt} = c\,p(1-p) - e\,p$, illustrated by the patch network below (filled = occupied, open = empty), the variable $p$ represents: **[1 mark]**



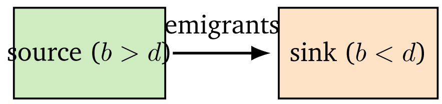

(A) the total number of individuals in the metapopulation

(B) the per-capita birth rate within a patch

(C) the number of individuals living in each patch

(D) the fraction of habitat patches that are currently occupied

**Q8.** In source–sink dynamics, sketched below, a habitat is classified as a "sink" when: **[1 mark]**




(A) births exceed deaths and it exports a surplus of emigrants

(B) local mortality exceeds local reproduction, so the population persists only through continued immigration

(C) the population is permanently locked at its carrying capacity

(D) no individuals are ever present in it

**Q9.** A metapopulation follows Levins' model with colonisation rate $c = 0.6$ and extinction rate $e = 0.3$. At equilibrium the occupied fraction is $\hat{p} = 1 - \frac{e}{c}$. The equilibrium value of $\hat{p}$ is: **[1 mark]**

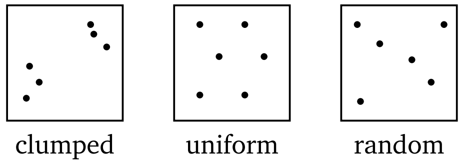
(A) $0.25$

(B) $0.50$

(C) $0.75$

(D) $0.00$

**Q10.** The three sampling quadrats below show different spatial arrangements of individuals. A pattern in which individuals occur in tight groups, typically because suitable resources are patchy, is described as: **[1 mark]**




(A) clumped (aggregated)

(B) uniform (regular)

(C) random

(D) linear

**Q11.** A population grows exponentially with intrinsic rate $r = 0.0231$ yr$^{-1}$. Its doubling time, given by $t_d = \dfrac{\ln 2}{r}$, is approximately (take $\ln 2 = 0.693$): **[1 mark]**

(A) 30 years

(B) 15 years

(C) 60 years

(D) 3 years

**Q12.** An interaction between two species in which one partner benefits while the other is neither helped nor harmed is called: **[1 mark]**

(A) mutualism

(B) commensalism

(C) parasitism

(D) interspecific competition

## Ecosystems and Biogeochemical Cycles

**Q13.** The process by which decomposers break down complex organic compounds in dead tissue and release simple inorganic nutrients ($CO_2$, water and mineral ions) back to the soil is called: **[1 mark]**

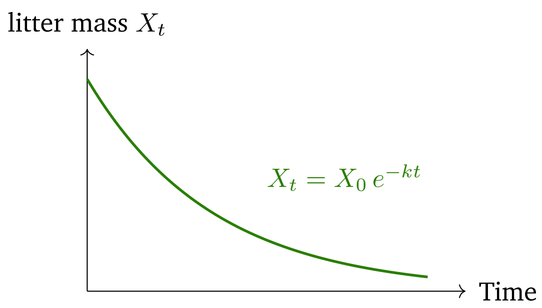
(A) immobilization

(B) gross primary production

(C) mineralization

(D) assimilation

**Q14.** Olson's model of litter decomposition, plotted below, is $X_t = X_0\, e^{-kt}$, where $X_t$ is the remaining litter mass at time $t$. In this expression the constant $k$ is the: **[1 mark]**




(A) annual litter input rate

(B) decomposition (decay) rate constant

(C) net primary productivity

(D) standing-crop biomass

**Q15.** Leaf litter on a forest floor decomposes with a decay constant $k = 0.25\ \text{yr}^{-1}$. The mean residence (turnover) time of the litter, equal to $\frac{1}{k}$, is: **[1 mark]**

(A) $4$ years

(B) $0.25$ years

(C) $2$ years

(D) $8$ years

**Q16.** Litter with a high carbon-to-nitrogen (C:N) ratio, such as woody debris, generally decomposes: **[1 mark]**

(A) very rapidly, because carbon is present in excess

(B) at a rate that is independent of the C:N ratio

(C) slowly, because the low nitrogen content limits decomposer growth

(D) only in the complete absence of microbes

**Q17.** A food chain that begins with dead organic matter (detritus) and passes through detritivores and decomposers, rather than starting with living green plants, is called a: **[1 mark]**

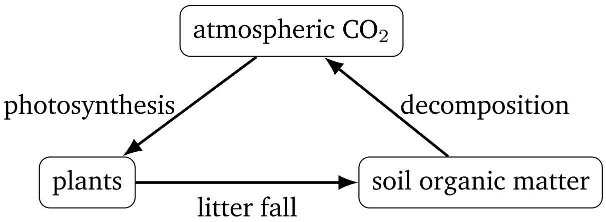
(A) grazing food chain

(B) detritus (decomposer) food chain

(C) parasitic food chain

(D) predatory food chain

**Q18.** In the simplified carbon cycle shown, during the decomposition of soil organic matter by microbes, carbon is returned to the atmosphere mainly as: **[1 mark]**




(A) carbon dioxide ($CO_2$) released by microbial respiration

(B) nitrogen gas ($N_2$)

(C) methane ($CH_4$) only, never $CO_2$

(D) elemental carbon (soot)

## Mechanisms of Evolution

**Q19.** The evolution of traits that raise an individual's success in acquiring mates, even when those traits reduce survival, is driven by: **[1 mark]**

(A) survival-based natural selection only

(B) artificial selection

(C) sexual selection

(D) kin selection

**Q20.** In evolutionary biology, the Darwinian fitness of a genotype is most correctly measured by its: [1 mark]

(A) relative reproductive contribution (surviving offspring) to the next generation

(B) adult body size

(C) maximum lifespan alone

(D) resting metabolic rate

**Q21.** Male deer that fight one another with their antlers to gain access to receptive females illustrate which component of sexual selection? [2 marks]

(A) intersexual selection (female choice)

(B) intrasexual selection (male–male competition)

(C) natural selection acting against large body size

(D) kin selection among the herd

**Q22.** In a population, genotype $AA$ leaves on average $6$ surviving offspring and genotype $aa$ leaves $3$. Taking the most productive genotype as the reference with fitness $w = 1$, the relative fitness of $aa$ is: [2 marks]

(A) $0.5$

(B) $2.0$

(C) $3.0$

(D) $1.0$

**Q23.** A pronounced difference in body size, colouration or ornamentation between the males and females of one species (as in the showy peacock versus the drab peahen) is termed: [2 marks]

(A) sexual monomorphism

(B) sexual dimorphism

(C) balanced polymorphism

(D) maximal heterozygosity

**Q24.** A newly arisen dominant lethal allele has fitness $w = 0$, so every carrier dies before reproducing. Among the individuals that actually reproduce in the very next generation, the frequency of this allele will be: **[2 marks]**

(A) unchanged from the parental generation

(B) doubled relative to the parents

(C) zero, because carriers are eliminated before breeding

(D) exactly $0.5$

## Population and Quantitative Genetics

**Q25.** Linkage disequilibrium between two loci refers to: **[2 marks]**

(A) a non-random (statistical) association between the alleles carried at two or more loci

(B) the physical breakage of a chromosome during meiosis

(C) a state in which all alleles occur at exactly equal frequency

(D) the complete absence of any genetic variation

**Q26.** For two loci, the linkage-disequilibrium coefficient is $D = f(AB) - f(A)\,f(B)$, where $f(AB)$ is the frequency of the $AB$ gamete. If $f(AB) = 0.40$, $f(A) = 0.5$ and $f(B) = 0.5$, then $D$ equals: **[2 marks]**

(A) $0.25$

(B) $0.15$

(C) $0.40$

(D) $0.00$

**Q27.** The inbreeding coefficient $F$ of an individual is defined as the probability that: **[2 marks]**

(A) the individual carries at least one new mutation

(B) two given loci are physically linked

(C) an allele is lost from the population by genetic drift

(D) the two alleles at a locus are identical by descent (inherited from a common ancestor)

**Q28.** A partially inbred population has allele frequencies $p = q = 0.5$ and inbreeding coefficient $F = 0.2$. Using the relation heterozygote frequency $= 2pq(1 - F)$, the frequency of heterozygotes is: **[2 marks]**

(A) $0.50$

(B) $0.10$

(C) $0.25$

(D) $0.40$

**Q29.** Under repeated strict self-fertilization (selfing), starting from a fully heterozygous line, the proportion of heterozygotes remaining in the population changes each generation by a factor of: **[2 marks]**

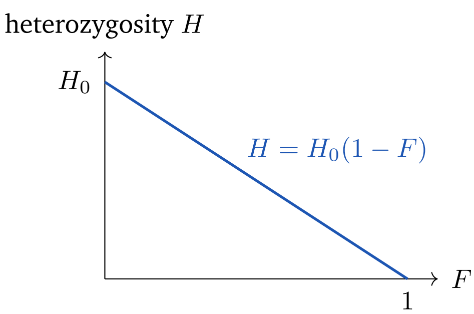
(A) one-half (it is halved every generation)

(B) it stays constant

(C) it doubles every generation

(D) one-quarter (it is quartered every generation)

**Q30.** The plot below shows how the observed heterozygosity $H$ of a population declines linearly with the inbreeding coefficient $F$ according to $H = H_0(1 - F)$. When inbreeding is complete ($F = 1$), the expected heterozygosity is: **[2 marks]**



(A) $H_0$

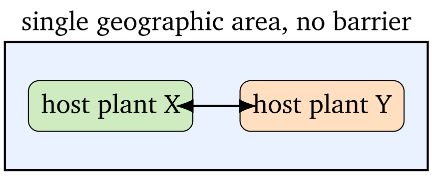
(B) $H_0/2$

(C) $0$

(D) $2H_0$

## Speciation, Phylogeny and Macroevolution

**Q31.** Speciation that occurs *without* any geographic barrier, while the diverging populations continue to live in the same area (for example, insect races specialising on different host plants), as depicted below, is called: **[2 marks]**




(A) allopatric speciation

(B) peripatric speciation

(C) parapatric speciation

(D) sympatric speciation

**Q32.** The most common route to essentially instantaneous sympatric speciation, particularly widespread among flowering plants, is: **[2 marks]**

(A) polyploidy (spontaneous doubling of the chromosome set)

(B) long-term geographic isolation on separate islands

(C) a slow founder effect at a range margin

(D) large-scale continental drift

**Q33.** Two closely related frog species breed in the same pond but at different times of the year, so their gametes never meet. This *prezygotic* isolating mechanism is an example of: **[2 marks]**

(A) mechanical isolation

(B) hybrid inviability

(C) temporal (seasonal) isolation

(D) gametic incompatibility

**Q34.** Two species mate and produce vigorous first-generation ($F_1$) hybrids, but when those hybrids reproduce, the second-generation ($F_2$) offspring are weak or sterile. This *postzygotic* isolating mechanism is called: **[2 marks]**

(A) hybrid inviability

(B) gametic isolation

(C) hybrid breakdown

(D) behavioural isolation

**Q35.** When two diverging populations meet again in a zone of secondary contact and their hybrids have low fitness, natural selection can strengthen the prezygotic barriers that reduce interbreeding. This process is called: **[2 marks]**

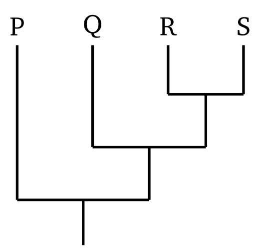
(A) introgression

(B) hybridization

(C) unrestricted gene flow

(D) reinforcement

**Q36.** In the cladogram below, the taxon that branches off at the deepest (root) node, and is therefore the outgroup most distantly related to the remaining taxa, is: **[2 marks]**



(A) P

(B) Q

(C) R

(D) S

## Behavioural Ecology

**Q37.** The inclusive fitness of an individual is the sum of its own direct reproductive success plus: **[2 marks]**

(A) the total size of the population it lives in

(B) the number of predators it manages to avoid

(C) the extra reproduction it causes in its relatives, each weighted by the coefficient of relatedness

(D) its own basal metabolic rate

**Q38.** An altruistic act costs the actor $C = 2$ offspring-equivalents and benefits a first cousin, for whom the coefficient of relatedness is $r = 0.125$, by $B$ offspring-equivalents. By Hamilton's rule $rB > C$, the act is favoured only if $B$ exceeds: **[2 marks]**

(A) 8

(B) 16

(C) 4

(D) 2

**Q39.** In haplodiploid social insects such as honeybees, where males are haploid and females diploid, full sisters share an unusually high average coefficient of relatedness of: **[2 marks]**

(A) 0.50

(B) 0.75

(C) 0.25

(D) 1.00

**Q40.** Unrelated vampire bats regurgitate blood to roost-mates that failed to feed, and are later repaid by those same individuals when their own foraging fails. This mutually beneficial exchange between non-kin is best explained by: **[2 marks]**

(A) reciprocal altruism

(B) kin selection acting on close relatives alone

(C) Zahavi's handicap principle

(D) recurrent mutation pressure

**Q41.** A gene for giving an alarm call spreads by kin selection when the call saves enough relatives. For an actor warning its half-siblings, for whom $r = 0.25$, an alarm call that costs the caller $C = 1$ offspring-equivalent is favoured (by $rB > C$) only when the number of full-value lives saved, $B$, exceeds: **[2 marks]**

(A) 1

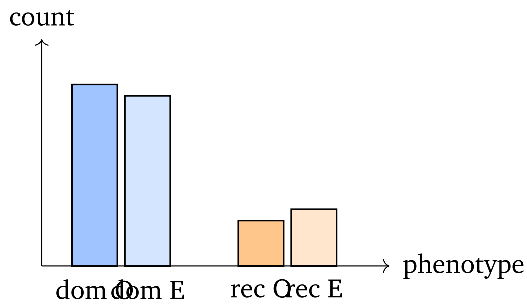
(B) 2

(C) 4

(D) 8

## Quantitative Ecology, Biostatistics and Mathematics

**Q42.** A monohybrid cross predicts a $3 : 1$ phenotypic ratio. Among 100 offspring, 80 show the dominant and 20 the recessive phenotype, whereas 75 and 25 are expected. The bars below compare observed (O) and expected (E) counts. The chi-square statistic $\chi^2 = \sum \frac{(O-E)^2}{E}$ equals: **[2 marks]**




(A) $0.33$

(B) $5.00$

(C) $2.67$

(D) $1.33$

**Q43.** For the monohybrid chi-square test above, which compares two phenotypic classes, the number of degrees of freedom (number of classes minus one) is: **[2 marks]**

(A) $1$

(B) $2$

(C) $3$

(D) $0$

**Q44.** The critical value of $\chi^2$ at $df = 1$ and significance level $\alpha = 0.05$ is $3.84$. Since the calculated value $1.33$ is less than $3.84$, the correct statistical conclusion is: **[2 marks]**

(A) reject the null hypothesis; the ratio is definitely not $3 : 1$

(B) the sample size is too small for any test to be valid

(C) the deviation is highly statistically significant

(D) fail to reject the null hypothesis; the data are consistent with the expected $3 : 1$ ratio

**Q45.** In hypothesis testing, a result is conventionally declared "statistically significant" at the $5\%$ level when the associated p-value is: **[2 marks]**

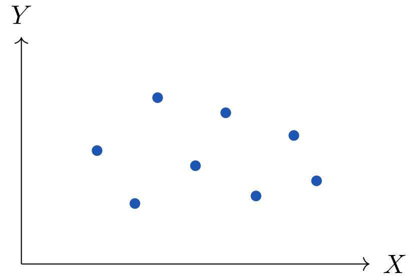
(A) greater than $0.5$

(B) exactly $1.0$

(C) greater than $0.05$

(D) less than $0.05$

**Q46.** The scatter plot below shows paired measurements of two variables $X$ and $Y$ that form a roughly circular cloud with no systematic upward or downward trend. The Pearson correlation coefficient $r$ for these data is best described as: **[2 marks]**




(A) close to $+1$

(B) approximately zero (no linear association)

(C) close to $-1$

(D) exactly $+1$

# Detailed Solutions

## Q1.

**Solution**

**Concept – Whittaker's biome scheme:** Whittaker plotted the world's major terrestrial biomes on a two-dimensional graph to show what governs where each one occurs.

**Step 1 – identify the two axes:** One axis is mean annual temperature and the other is mean annual precipitation.

**Step 2 – read the pattern:** Hot and wet corners hold rainforest, hot and dry corners hold desert, cold corners hold tundra, and intermediate rainfall gives grassland.

**Step 3 – reject the other options:** Latitude and longitude only set location, while soil pH, altitude, day length and wind are secondary, not the primary climatic axes.

**Final Answer:** mean annual temperature and mean annual precipitation $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q1

## Q2.

**Solution**

**Concept – the desert biome:** Deserts are defined by very low and unreliable rainfall, generally below about 25 cm a year.

**Step 1 – match the rainfall figure:** Less than 25 cm of annual rainfall is the classic threshold for a desert.

**Step 2 – match the vegetation:** Sparse, water-conserving plants such as succulents and deep-rooted shrubs are typical of deserts.

**Step 3 – reject the others:** Rainforest is very wet, grassland receives moderate rain, and tundra is defined by cold, not by extreme dryness alone.

**Final Answer:** desert $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

## Q3.

**Solution**

**Concept – the tundra biome:** The tundra rings the poles and high mountains, where cold dominates the climate.

**Step 1 – match the key features:** Permafrost, very low temperatures and a short growing season are diagnostic of tundra.

**Step 2 – confirm the location:** Such conditions occur at very high latitudes near the poles.

**Step 3 – reject the others:** Savanna and tropical deciduous forest are warm biomes, and chaparral is a mild, dry Mediterranean shrubland.

**Final Answer:** tundra $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

## Q4.

**Solution**

**Concept – the ecotone:** An ecotone is the boundary region where two communities meet and blend.

**Step 1 – read the figure:** The strip lies between a forest and a grassland and carries features of both.

**Step 2 – name the zone:** A transition zone between two communities is an ecotone, and it often shows high richness (the edge effect).

**Step 3 – reject the others:** A biome is a large region, a niche is a functional role, and an ecocline is a gradual gradient rather than a sharp transition strip.

**Final Answer:** ecotone $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q4

## Q5.

**Solution**

**Concept – reading a climate diagram:** In a Walter climate diagram the temperature and precipitation curves are drawn on scales chosen so their relative height signals water availability.

**Step 1 – recall the convention:** When the precipitation curve dips below the temperature curve, evaporation demand outstrips rainfall.

**Step 2 – identify the arid months:** Those months, where precipitation lies under the temperature line, form the drought (arid) period.

**Step 3 – reject the others:** High rainfall or precipitation above the temperature line marks a wet period, and freezing temperature is a separate cold signal, not the arid criterion.

**Final Answer:** the precipitation curve falls below the temperature curve $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q5

## Q6.

### Solution

**Concept – Bergmann's rule:** Within a warm-blooded species, individuals in colder climates tend to be larger because a bigger body has a smaller surface-area-to-volume ratio and loses heat more slowly.

**Step 1 – link size to heat loss:** Larger animals conserve body heat better in the cold.

**Step 2 – name the rule:** This body-size trend along a temperature gradient is Bergmann's rule.

**Step 3 – reject the others:** Allen's rule concerns the length of appendages, Gloger's rule concerns pigmentation, and Cope's rule concerns size increase over evolutionary time.

**Final Answer:** Bergmann's rule $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q6

## Q7.

### Solution

**Concept – Levins' metapopulation model:** Levins tracks not individuals but the state of the patches. Each patch is either occupied or empty.

**Step 1 – interpret $p$:** $p$ is the proportion of all suitable habitat patches that are occupied at a given time.

**Step 2 – read the two terms:** $c\,p(1-p)$ is colonisation of empty patches, and $e\,p$ is extinction of occupied patches.

**Step 3 – reject the others:** The model does not follow total numbers, per-patch densities, or birth rates; it follows patch occupancy.

**Final Answer:** the fraction of habitat patches currently occupied $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

## Q8.

### Solution

**Concept – source and sink habitats:** In a source the local birth rate exceeds the death rate, so it produces a surplus; in a sink the death rate exceeds the birth rate.

**Step 1 – define a sink:** A sink has $b < d$, so on its own it would decline to zero.

**Step 2 – explain its persistence:** It is kept occupied only because immigrants keep arriving from nearby sources.

**Step 3 – reject the others:** Exporting a surplus describes a source, and a sink is neither locked at carrying capacity nor permanently empty.

**Final Answer:** local mortality exceeds local reproduction, persisting only through immigration $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

## Q9.

### Solution

**Concept – equilibrium occupancy in Levins' model:** At equilibrium the occupied fraction is $\hat{p} = 1 - \dfrac{e}{c}$.

**Step 1 – list the data:** $c = 0.6$ and $e = 0.3$.

**Step 2 – form the ratio:** $\dfrac{e}{c} = \dfrac{0.3}{0.6} = 0.5$

**Step 3 – subtract from one:** $\hat{p} = 1 - 0.5 = 0.5$

**Step 4 – interpret:** At equilibrium half of the patches are occupied.

**Final Answer:** $\hat{p} = 0.50 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

## Q10.

### Solution

**Concept – spatial dispersion patterns:** Individuals can be spread in three ways: clumped, uniform or random.

**Step 1 – read the requirement:** Individuals occur in tight groups because resources are patchy.

**Step 2 – match the pattern:** Grouping around favourable patches is the clumped (aggregated) pattern, the most common one in nature.

**Step 3 – reject the others:** Uniform spacing comes from competition or territoriality, random spacing implies no interaction, and linear is not a standard dispersion class.

**Final Answer:** clumped (aggregated) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q10

## Q11.

### Solution

**Concept – doubling time of exponential growth:** When a population grows exponentially it doubles after a fixed time $t_d = \dfrac{\ln 2}{r}$.

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

**Step 2 – substitute into the formula:** $t_d = \dfrac{0.693}{0.0231}$

**Step 3 – evaluate:** $t_d = 30$ years

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

Answer: (A) Go Back to Q11

## Q12.

### Solution

**Concept – classifying species interactions:** Interactions are named by the sign of the effect on each partner.

**Step 1 – read the signs:** One species gains $(+)$ and the other is unaffected $(0)$.

**Step 2 – name the interaction:** A $(+, 0)$ interaction is commensalism.

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

**Final Answer:** commensalism $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

## Q13.

**Solution**

**Concept – mineralization:** Mineralization is the microbial conversion of organically bound nutrients back into inorganic forms available to plants.

**Step 1 – read the description:** Decomposers break down dead tissue and release $CO_2$, water and mineral ions.

**Step 2 – name the process:** Releasing inorganic nutrients from organic matter is mineralization.

**Step 3 – reject the others:** Immobilization locks nutrients into microbial biomass, primary production builds organic matter, and assimilation is uptake into tissue.

**Final Answer:** mineralization $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q13

## Q14.

**Solution**

**Concept – Olson's decomposition model:** Litter mass declines exponentially as $X_t = X_0\, e^{-kt}$, exactly like radioactive decay.

**Step 1 – identify each symbol:** $X_0$ is the starting mass and $X_t$ is the mass left at time $t$.

**Step 2 – interpret $k$:** $k$ sets how fast the mass is lost, so it is the decomposition (decay) rate constant.

**Step 3 – reject the others:** Litter input, productivity and standing biomass are separate quantities, not the exponent that controls the decay.

**Final Answer:** the decomposition (decay) rate constant $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q14

## Q15.

**Solution**

**Concept – turnover time from a decay constant:** For exponential decay the mean residence time equals the reciprocal of the rate constant, $\frac{1}{k}$.

**Step 1 – list the data:** $k = 0.25\ \text{yr}^{-1}$.

**Step 2 – take the reciprocal:** $\frac{1}{k} = \frac{1}{0.25}$

**Step 3 – evaluate:** $\dfrac{1}{0.25} = 4$ years

**Final Answer:** 4 years $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

## Q16.

### Solution

**Concept – C:N ratio and decomposition:** Decomposers need nitrogen to build their own bodies; a shortage of nitrogen slows them down.

**Step 1 – read the litter quality:** A high C:N ratio means plenty of carbon but little nitrogen.

**Step 2 – predict the rate:** The scarce nitrogen limits microbial growth, so such litter decomposes slowly.

**Step 3 – reject the others:** Excess carbon alone does not speed decay, the rate clearly does depend on C:N, and microbes are certainly involved.

**Final Answer:** slowly, because low nitrogen limits decomposer activity $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q16

## Q17.

### Solution

**Concept – detritus food chains:** Energy can enter a food web either through living plants or through dead organic matter.

**Step 1 – read the starting point:** This chain begins with detritus and moves through detritivores and decomposers.

**Step 2 – name the chain:** A chain founded on dead matter is a detritus (decomposer) food chain.

**Step 3 – reject the others:** A grazing chain starts with green plants, while the parasitic and predatory labels describe other feeding relationships.

**Final Answer:** detritus (decomposer) food chain $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

## Q18.

**Solution**

**Concept – carbon return during decomposition:** Soil microbes oxidise organic carbon for energy and release it as a gas.

**Step 1 – read the figure:** The decomposition arrow runs from soil organic matter back to atmospheric $CO_2$.

**Step 2 – name the gas:** Aerobic microbial respiration releases carbon dioxide, closing the loop.

**Step 3 – reject the others:** $N_2$ belongs to the nitrogen cycle, methane forms only under anaerobic conditions, and soot is not a normal product of decomposition.

**Final Answer:** $CO_2$ released by microbial respiration $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q18

## Q19.

**Solution**

**Concept – sexual selection:** Some traits raise mating success even though they lower survival; they spread through sexual selection.

**Step 1 – read the requirement:** The trait improves mate acquisition at a survival cost.

**Step 2 – name the force:** Selection acting through mating success is sexual selection.

**Step 3 – reject the others:** Ordinary natural selection favours survival, artificial selection is imposed by breeders, and kin selection works through relatives.

**Final Answer:** sexual selection $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q19

## Q20.

**Solution**

**Concept – Darwinian fitness:** Fitness measures how many offspring a genotype contributes to the next generation relative to others.

**Step 1 – state the definition:** Fitness is the relative number of surviving, reproducing offspring left behind.

**Step 2 – apply it:** The genotype that passes on the most descendants has the highest fitness.

**Step 3 – reject the others:** Body size, lifespan and metabolic rate matter only insofar as they change reproductive output.

**Final Answer:** relative reproductive contribution to the next generation $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

## Q21.

### Solution

**Concept – two components of sexual selection:** Sexual selection acts either through competition among the same sex (intrasexual) or through mate choice by the other sex (intersexual).

**Step 1 – read the scenario:** Males fight other males with antlers to win females.

**Step 2 – classify the competition:** Contest between members of the same sex is intrasexual selection.

**Step 3 – reject the others:** Female choice is intersexual, and neither survival selection against size nor kin selection describes male combat.

**Final Answer:** intrasexual selection (male–male competition) $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

## Q22.

### Solution

**Concept – relative fitness:** Relative fitness scales each genotype's offspring output against the best-performing genotype, which is set to $w = 1$.

**Step 1 – list the data:** $AA$ leaves $6$ offspring and $aa$ leaves $3$.

**Step 2 – pick the reference:** The best is $AA$ with $6$, so it gets $w = 1$.

**Step 3 – form the ratio for $aa$:** $w_{aa} = \dfrac{3}{6}$

**Step 4 – evaluate:** $w_{aa} = 0.5$

**Final Answer:** $0.5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q22

## Q23.

### Solution

**Concept – sexual dimorphism:** When the two sexes of one species differ markedly in appearance, they are sexually dimorphic.

**Step 1 – read the example:** The showy peacock and the drab peahen differ strongly in ornament and colour.

**Step 2 – name the pattern:** Such between-sex difference is sexual dimorphism, often a product of sexual selection.

**Step 3 – reject the others:** Monomorphism means the sexes look alike, polymorphism refers to variants within a population, and heterozygosity is a genetic, not a visible-sex, measure.

**Final Answer:** sexual dimorphism $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

## Q24.

### Solution

**Concept – selection against a lethal allele:** An allele with fitness $w = 0$ contributes no offspring to the next generation.

**Step 1 – read the fitness:** The dominant lethal has $w = 0$, so every carrier dies before it can breed.

**Step 2 – trace the reproducing pool:** Only non-carriers survive to reproduce, so no copies of the allele are passed on.

**Step 3 – state the frequency:** Among the individuals that actually reproduce, the allele frequency is zero.

**Step 4 – reject the others:** It cannot stay unchanged, double, or sit at $0.5$ when carriers never breed.

**Final Answer:** zero, because carriers are eliminated before breeding $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

## Q25.

**Solution**

**Concept – linkage disequilibrium:** Linkage disequilibrium is a statistical, not a physical, idea: it measures whether alleles at different loci travel together more or less often than chance predicts.

**Step 1 – state the definition:** It is a non-random association between the alleles carried at two or more loci.

**Step 2 – contrast with equilibrium:** At linkage equilibrium the alleles combine independently, giving $D = 0$.

**Step 3 – reject the others:** It is not chromosome breakage, not equal allele frequencies, and not the absence of variation.

**Final Answer:** a non-random association between alleles at two or more loci $\Rightarrow$ $\boxed{\text{A}}$

**Answer: (A)** Go Back to Q25

## Q26.

**Solution**

**Concept – the LD coefficient $D$:** $D$ compares the observed frequency of a haplotype with the product expected if the loci were independent.

**Step 1 – list the data:** $f(AB) = 0.40$, $f(A) = 0.5$, $f(B) = 0.5$.

**Step 2 – compute the expected product:** $f(A)\,f(B) = 0.5 \times 0.5 = 0.25$

**Step 3 – subtract from the observed:** $D = 0.40 - 0.25$

**Step 4 – evaluate:** $D = 0.15$

**Final Answer:** $D = 0.15 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q26

## Q27.

**Solution**

**Concept – the inbreeding coefficient:** $F$ is a probability that captures how likely an individual's two gene copies at a locus trace back to the same ancestral copy.

**Step 1 – state the definition:** $F$ is the probability that the two alleles at a locus are identical by descent.

**Step 2 – interpret its effect:** Higher $F$ means more homozygosity, because the paired alleles are copies of one ancestral allele.

**Step 3 – reject the others:** $F$ is not about new mutation, physical linkage, or the loss of an allele by drift.

**Final Answer:** the two alleles at a locus are identical by descent $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q27

## Q28.

**Solution**

**Concept – heterozygosity under inbreeding:** Inbreeding reduces the heterozygote frequency to $2pq(1-F)$ instead of the Hardy–Weinberg value $2pq$.

**Step 1 – list the data:** $p = q = 0.5$ and $F = 0.2$.

**Step 2 – compute the random-mating part:** $2pq = 2 \times 0.5 \times 0.5 = 0.5$

**Step 3 – apply the inbreeding factor:** $2pq(1-F) = 0.5 \times (1-0.2)$

**Step 4 – evaluate:** $0.5 \times 0.8 = 0.4$

**Final Answer:** $0.40 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q28

## Q29.

**Solution**

**Concept – selfing and heterozygosity:** When a heterozygote $Aa$ self-fertilizes, its offspring are $\frac{1}{4}\,AA : \frac{1}{2}\,Aa : \frac{1}{4}\,aa$.

**Step 1 – track the heterozygotes:** Only half of a heterozygote's selfed offspring are themselves heterozygous.

**Step 2 – state the recurrence:** So the heterozygote frequency is multiplied by $\frac{1}{2}$ each generation.

**Step 3 – reject the others:** It cannot stay constant, double, or fall by a quarter; halving is the correct rate.

**Final Answer:** it is halved every generation $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

## Q30.

### Solution

**Concept – heterozygosity as a function of $F$:** The line $H = H_0(1 - F)$ shows heterozygosity falling straight from $H_0$ at $F = 0$ toward zero as $F$ rises.

**Step 1 – set $F = 1$:** Substitute complete inbreeding into the equation.

**Step 2 – evaluate the bracket:** $1 - F = 1 - 1 = 0$

**Step 3 – multiply:** $H = H_0 \times 0 = 0$

**Step 4 – interpret:** With complete inbreeding every individual is homozygous, so heterozygosity vanishes.

**Final Answer:** $H = 0 \Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q30

## Q31.

### Solution

**Concept – sympatric speciation:** Sympatric speciation produces new species with no geographic separation; divergence happens within a single area.

**Step 1 – read the figure:** Both diverging groups share one area with no barrier, splitting instead by host-plant use.

**Step 2 – name the mode:** Divergence within the same location is sympatric speciation.

**Step 3 – reject the others:** Allopatric and peripatric speciation need geographic isolation, and parapatric speciation involves adjoining ranges with a gradient, not full overlap.

**Final Answer:** sympatric speciation $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q31

## Q32.

### Solution

**Concept – polyploidy as instant speciation:** A doubling of the chromosome set can create a new, reproductively isolated plant species in a single generation, right alongside its parents.

**Step 1 – read the requirement:** We need the common, essentially instantaneous sympatric route, especially in plants.

**Step 2 – name the mechanism:** Polyploidy fits, because a tetraploid cannot breed successfully with its diploid parent.

**Step 3 – reject the others:** Island isolation, a founder effect and continental drift all involve geography or slow change, not instant sympatric divergence.

**Final Answer:** polyploidy (chromosome doubling) $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q32

## Q33.

### Solution

**Concept – temporal isolation:** A prezygotic barrier stops mating or fertilization before a zygote forms. Timing is one such barrier.

**Step 1 – read the scenario:** The two frog species breed in the same pond but in different seasons.

**Step 2 – name the barrier:** Breeding at different times is temporal (seasonal) isolation, acting before fertilization.

**Step 3 – reject the others:** Mechanical isolation is a structural mismatch, gametic incompatibility acts at the gamete level, and hybrid inviability is postzygotic.

**Final Answer:** temporal (seasonal) isolation $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q33

## Q34.

### Solution

**Concept – hybrid breakdown:** A postzygotic barrier reduces the fitness of hybrids after fertilization. Hybrid breakdown appears one generation late.

**Step 1 – read the pattern:** The $F_1$ hybrids are healthy, but the $F_2$ generation is weak or sterile.

**Step 2 – name the barrier:** Loss of fitness in the second hybrid generation is hybrid breakdown.

**Step 3 – reject the others:** Hybrid inviability would already harm the $F_1$, gametic isolation and behavioural isolation are prezygotic.

**Final Answer:** hybrid breakdown $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q34

## Q35.

**Solution**

**Concept – reinforcement:** When hybrids are unfit, selection favours individuals that avoid mating across the two groups, strengthening prezygotic barriers.

**Step 1 – read the scenario:** Populations meet again in secondary contact and their hybrids do poorly.

**Step 2 – name the process:** Selection against costly hybridization that boosts assortative mating is reinforcement.

**Step 3 – reject the others:** Introgression and hybridization move genes across the boundary, and unrestricted gene flow would merge the groups rather than separate them.

**Final Answer:** reinforcement $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q35

## Q36.

**Solution**

**Concept – reading an outgroup on a cladogram:** The taxon attached at the deepest node splits from all the others first and serves as the outgroup.

**Step 1 – trace the branching:** Q, R and S join through shallower nodes, while P connects only at the basal (root) node.

**Step 2 – identify the earliest split:** P diverges before the others share any common ancestor among themselves.

**Step 3 – name the outgroup:** Therefore P is the outgroup, most distantly related to Q, R and S.

**Final Answer:** P $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q36

## Q37.

**Solution**

**Concept – inclusive fitness:** Inclusive fitness adds an individual's own reproduction to the reproduction it helps its relatives achieve, discounted by relatedness.

**Step 1 – write the two parts:** Direct fitness is the individual's own offspring; indirect fitness is the extra offspring of relatives.

**Step 2 – weight the indirect part:** Each relative's contribution is multiplied by the coefficient of relatedness $r$.

**Step 3 – reject the others:** Population size, predators avoided and metabolic rate are not components of inclusive fitness.

**Final Answer:** the extra reproduction of relatives, weighted by relatedness $\Rightarrow \boxed{\text{C}}$

**Answer: (C)** Go Back to Q37

## Q38.

**Solution**

**Concept – Hamilton's rule:** Altruism is favoured when $rB > C$, so the benefit must clear the threshold $B > \dfrac{C}{r}$.

**Step 1 – list the data:** $C = 2$ and $r = 0.125$ for a first cousin.

**Step 2 – rearrange the rule:** $B > \dfrac{C}{r} = \dfrac{2}{0.125}$

**Step 3 – evaluate:** $\dfrac{2}{0.125} = 16$

**Step 4 – interpret:** The act pays off only if it gives the cousin more than 16 offspring-equivalents.

**Final Answer:** $B$ must exceed $16 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q38

## Q39.

**Solution**

**Concept – relatedness under haplodiploidy:** Because haploid fathers pass an identical set of genes to all daughters, full sisters are more related than in diploids.

**Step 1 – combine the two contributions:** Sisters share all of the father's genes ($r = 1$ for the paternal half) and half of the mother's.

**Step 2 – average them:** $r = \frac{1}{2}(1) + \frac{1}{2}(0.5) = 0.5 + 0.25 = 0.75$

**Step 3 – interpret:** This high relatedness helps explain the evolution of sterile worker castes.

**Final Answer:** $0.75 \Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q39

## Q40.

**Solution**

**Concept – reciprocal altruism:** Help exchanged between unrelated individuals can evolve when donors are repaid later, provided cheats are detected and excluded.

**Step 1 – read the scenario:** Unrelated bats feed each other and expect repayment in future.

**Step 2 – name the mechanism:** Repeated give-and-take among non-kin is reciprocal altruism.

**Step 3 – reject the others:** Kin selection needs relatives, the handicap principle explains costly signals, and mutation pressure is unrelated to cooperation.

**Final Answer:** reciprocal altruism $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q40

## Q41.

**Solution**

**Concept – Hamilton's rule for alarm calls:** The call spreads when $rB > C$, i.e. $B > \frac{C}{r}$.

**Step 1 – list the data:** $C = 1$ and $r = 0.25$ for half-siblings.

**Step 2 – rearrange the rule:** $B > \frac{C}{r} = \frac{1}{0.25}$

**Step 3 – evaluate:** $\frac{1}{0.25} = 4$

**Step 4 – interpret:** The alarm call is favoured only if it saves more than four full-value relatives.

**Final Answer:** $B$ must exceed $4 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q41

## Q42.

**Solution**

**Concept – the chi-square goodness-of-fit test:** $\chi^2$ adds up the squared deviations of observed from expected counts, each scaled by the expected count.

**Step 1 – list the counts:** Dominant: $O = 80$, $E = 75$. Recessive: $O = 20$, $E = 25$.

**Step 2 – the dominant term:** $\frac{(80-75)^2}{75} = \frac{25}{75} = 0.333$

**Step 3 – the recessive term:** $\dfrac{(20-25)^2}{25} = \dfrac{25}{25} = 1.000$

**Step 4 – add the terms:** $\chi^2 = 0.333 + 1.000 = 1.333 \approx 1.33$

**Final Answer:** $\chi^2 \approx 1.33 \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q42

## Q43.

### Solution

**Concept – degrees of freedom in a goodness-of-fit test:** For a simple goodness-of-fit test the degrees of freedom equal the number of categories minus one.

**Step 1 – count the classes:** There are two phenotypic classes, dominant and recessive.

**Step 2 – apply the rule:** $df = (\text{number of classes}) - 1 = 2 - 1$

**Step 3 – evaluate:** $df = 1$

**Final Answer:** $df = 1 \Rightarrow \boxed{\text{A}}$

**Answer: (A)** Go Back to Q43

## Q44.

### Solution

**Concept – comparing $\chi^2$ with its critical value:** If the calculated $\chi^2$ is smaller than the critical value, the deviation is within chance and the null hypothesis stands.

**Step 1 – state the two values:** Calculated $\chi^2 = 1.33$ and critical value $= 3.84$.

**Step 2 – compare them:** $1.33 < 3.84$, so the deviation is not significant.

**Step 3 – draw the conclusion:** We fail to reject the null hypothesis; the observed counts fit the expected $3:1$ ratio.

**Step 4 – reject the others:** The result is not significant, the sample is adequate, and there is no ground to reject the ratio.

**Final Answer:** fail to reject the null; the data fit the $3:1$ ratio $\Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q44

## Q45.

**Solution**

**Concept – statistical significance and the p-value:** The p-value is the probability of a result as extreme as the one observed if the null hypothesis were true.

**Step 1 – recall the $5\%$ rule:** Significance at the $5\%$ level means the p-value falls below $0.05$.

**Step 2 – interpret the threshold:** A small p-value signals that chance alone is an unlikely explanation.

**Step 3 – reject the others:** Values above $0.05$, above $0.5$, or equal to $1.0$ all indicate a result consistent with chance.

**Final Answer:** less than $0.05 \Rightarrow \boxed{\text{D}}$

**Answer: (D)** Go Back to Q45

## Q46.

**Solution**

**Concept – correlation and scatter:** The correlation coefficient $r$ measures the strength and direction of a linear relationship, ranging from $-1$ to $+1$.

**Step 1 – read the scatter:** The points form a roughly circular cloud with no rising or falling trend.

**Step 2 – fix the value:** With no linear pattern, $Y$ does not track $X$, so $r$ is near zero.

**Step 3 – reject the others:** Values near $+1$ or $-1$ would require a tight upward or downward line, which is absent here.

**Final Answer:** approximately zero (no linear association) $\Rightarrow \boxed{\text{B}}$

**Answer: (B)** Go Back to Q46

## Answer Key

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