NSO-Style · Original Practice Content

Class 10 | Science Olympiad

40 Questions · With Answer Key
Syllabax Olympiad Series
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Instructions: Each question has one correct answer. Choose the best option (A/B/C/D). Answer key is provided at the end. This paper is for practice only — not an official exam paper. Recommended time: **45 minutes**.

Q1. The Yang-Mills existence and mass gap problem (one of the Millennium Prize Problems) concerns:

A. a mathematical proof that gauge theories have solutions with a positive mass gap

B. the mass of the Higgs boson

C. the existence of dark matter

D. solutions to the Navier-Stokes equations

Q2. In quantum field theory, the vacuum is not empty but filled with:

A. dark matter particles

B. real photons at rest

C. zero-point energy fluctuations (virtual particle-antiparticle pairs)

D. neutrinos only

Q3. The Casimir effect arises from:

A. gravitational attraction between parallel plates

B. electrostatic attraction between conducting plates

C. quantum vacuum fluctuations causing an attractive force between uncharged conducting plates

D. van der Waals forces at long range

Q4. In chromatin immunoprecipitation (ChIP-seq), the goal is to identify:

A. mRNA expression levels genome-wide

B. protein-coding sequences

C. genome-wide binding sites of a specific protein (e.g. transcription factor) or histone modification

D. mutations in the exome

Q5. The Kibble-Zurek mechanism describes defect formation when a system is:

A. cooled rapidly through a phase transition

B. heated above the Curie temperature

C. placed in a strong magnetic field

D. subjected to radiation damage

Q6. In synthetic biology, orthogonal ribosomes are engineered to:

A. translate only non-standard codons, decoupled from normal cellular translation

B. produce more ATP

C. replicate DNA faster

D. degrade unwanted proteins

Q7. The Laughlin wavefunction describes the ground state of:

A. superfluid helium-4

B. Bose-Einstein condensates

C. the fractional quantum Hall effect

D. Type II superconductors

Q8. In climate science, the equilibrium climate sensitivity (ECS) is defined as:

A. the temperature change per decade

B. the global mean surface temperature increase from a doubling of CO_2 at equilibrium

C. the ocean heat uptake rate

D. the radiative forcing from solar variation

Q9. The concept of 'mutational robustness' in evolutionary biology means:

A. mutations are repaired perfectly by DNA polymerase

B. the phenotype is insensitive to most mutations due to genetic redundancy and buffering

C. mutations are always beneficial

D. organisms accumulate mutations without limit

Q10. AdS/CFT correspondence (Maldacena conjecture) proposes a duality between:

A. quantum gravity in anti-de Sitter space and a conformal field theory on its boundary

B. general relativity and quantum mechanics

C. string theory and loop quantum gravity

D. electrodynamics and gravitation

Q11. In single-molecule biophysics, the persistence length of DNA is approximately:

A. 3.4 nm

B. 50 nm

C. 500 nm

D. 2 μm

Q12. The Fano resonance in spectroscopy arises from:

A. coupling between a discrete quantum state and a continuum of states

B. transitions between two bound states

C. spontaneous emission

D. Raman scattering

Q13. Which describes the concept of 'evo-devo' (evolutionary developmental biology)?

A. studying how genetic drift causes evolution

B. using computational models to simulate evolution

C. understanding how developmental mechanisms evolve and constrain or enable morphological diversity

D. applying classical genetics to developmental disorders

Q14. The Landauer principle in information theory states that erasing one bit of information dissipates at least:

A. hν energy

B. kT energy

C. kT ln2 energy

D. zero energy if reversible

Q15. In cosmology, the 'horizon problem' is solved by:

A. general relativity

B. dark energy

C. cosmic inflation

D. quantum gravity

Q16. In systems biology, a 'toggle switch' gene circuit:

A. oscillates between states periodically

B. switches irreversibly to a single state

C. maintains bistability, switching between two stable states depending on inputs

D. amplifies gene expression linearly

Q17. Topological insulators are materials that:

A. insulate perfectly at all temperatures

B. conduct electricity only at the surface due to topological properties, while being insulating in the bulk

C. have zero electrical resistance

D. are transparent to all electromagnetic radiation

Q18. The maximum efficiency of a photovoltaic cell (Shockley-Queisser limit) for a single-junction cell is approximately:

A. 100%

B. ~85%

C. ~33%

D. ~10%

Q19. In evolutionary game theory, an evolutionarily stable strategy (ESS) is one that:

A. always wins against any other strategy

B. cannot be invaded by any alternative strategy when it is common in the population

C. is always cooperative

D. maximises individual fitness regardless of the population

Q20. Single-cell RNA sequencing (scRNA-seq) allows:

A. measuring protein levels in single cells

B. sequencing the genome of a single bacterium

C. profiling the transcriptome of individual cells to reveal cell-type diversity

D. editing genes in individual cells

Q21. The Pontryagin maximum principle is used in:

A. quantum mechanics

B. optimal control theory to find the control that maximises or minimises an objective functional

C. thermodynamics to find equilibrium states

D. statistical mechanics

Q22. In string theory, the number of spatial dimensions in superstring theory is:

A. 4

B. 7

C. 9

D. 10

Q23. The Drude model of electrical conductivity assumes that electrons:

A. move in quantised energy levels

B. have wave properties that determine conductivity

C. are treated as classical particles undergoing collisions with lattice ions

D. interact quantum mechanically via the exchange interaction

Q24. In metabolomics, the 'metabolome' refers to:

A. the complete set of genes in an organism

B. all proteins expressed in a cell

C. the complete set of small molecule metabolites in a biological sample

D. the set of all enzymatic reactions

Q25. A Penrose diagram compactifies spacetime to represent:

A. the internal structure of atoms

B. particle collisions

C. causal structure of spacetimes including infinities in a finite diagram

D. geodesic motion in flat spacetime

Q26. The Born-Oppenheimer approximation in quantum chemistry separates:

A. spin-up and spin-down electrons

B. orbital and spin angular momentum

C. nuclear and electronic motion (because nuclei are much heavier and move more slowly)

D. sigma and pi bonds

Q27. In neuroscience, the 'binding problem' asks:

A. how the brain stores memories permanently

B. how neurochemical receptors bind neurotransmitters

C. how separate neural representations of different features are integrated into a unified conscious perception

D. how the brain develops in utero

Q28. Tensor networks (e.g. MERA, PEPS) in quantum information theory represent:

A. matrices of gene expression data

B. protein interaction networks

C. highly entangled quantum many-body states efficiently, capturing area-law entanglement

D. neural network architectures

Q29. The Langmuir adsorption isotherm assumes:

A. multilayer adsorption on heterogeneous surfaces

B. monolayer adsorption on equivalent, independent sites with no lateral interactions

C. physisorption only

D. chemisorption with variable binding energy

Q30. Which of the following correctly describes synthetic lethality in cancer therapy?

A. using two drugs that each kill cells on their own

B. targeting a single oncogene with high-dose chemotherapy

C. exploiting the fact that loss of gene A is lethal only when combined with loss of gene B (both mutations together are lethal; each alone is viable)

D. radiation therapy combined with surgery

Q31. The Mpemba effect (hot water freezing faster than cold water in some conditions) remains scientifically controversial. The most rigorously proposed mechanism involves:

A. convection currents in hot water

B. evaporative cooling of hot water

C. hydrogen bond network differences between hot and cold water affecting cooling dynamics

D. dissolved gas release from hot water

Q32. In radio astronomy, the 21 cm hydrogen line is produced by:

A. rotational transitions of H_2

B. a hyperfine transition due to the spin-flip of the electron in the hydrogen atom

C. Lyman-alpha emission

D. bremsstrahlung radiation

Q33. In evolutionary biology, the 'Red Queen hypothesis' proposes that:

A. species must constantly adapt and evolve merely to maintain fitness relative to co-evolving organisms (e.g., parasites)

B. dominant species suppress others

C. evolution always leads to more complex organisms

D. extinction is inevitable for all species

Q34. The Efimov effect predicts that three-body quantum systems can have:

A. exactly three bound states

B. no bound states when two-body interactions are repulsive

C. an infinite series of three-body bound states near a two-body resonance

D. bound states only at absolute zero

Q35. Optogenetics uses light-gated ion channels (channelrhodopsins) to:

A. image neurons with high resolution

B. sequence neuronal DNA

C. control neuronal activity with light, allowing precise manipulation of specific neuron populations

D. measure synaptic vesicle fusion

Q36. The maximum entropy principle (MaxEnt) in statistical mechanics and information theory states that:

A. entropy always decreases in biological systems

B. the least biased probability distribution consistent with known constraints maximises entropy

C. entropy and information are unrelated

D. biological complexity reduces entropy

Q37. In materials science, the Hall-Petch relationship states that yield strength ___ as grain size decreases.

A. decreases

B. stays the same

C. oscillates

D. increases

Q38. The concept of 'exaptation' in evolutionary biology refers to:

A. adaptive radiation into new environments

B. a trait originally evolved for one purpose later co-opted for a different function

C. convergent evolution of similar traits

D. the loss of vestigial organs

Q39. In general relativity, the Einstein field equations relate:

A. mass and energy equivalence

B. the geometry of spacetime (curvature) to the distribution of matter and energy

C. the speed of light to gravitational force

D. quantum states to gravitational fields

Q40. The concept of 'information paradox' in black hole physics arises because:

A. black holes cannot be observed directly

B. Hawking radiation appears thermal, suggesting information about infalling matter is lost, violating unitarity in quantum mechanics

C. the singularity at the centre has infinite density

D. black holes violate conservation of mass

Answer Key

Q1: A Q2: C Q3: C Q4: C Q5: A Q6: A Q7: C Q8: B Q9: B Q10: A

Q11: B Q12: A Q13: C Q14: C Q15: C Q16: C Q17: B Q18: C Q19: B

Q20: C Q21: B Q22: C Q23: C Q24: C Q25: C Q26: C Q27: C Q28: C

Q29: B Q30: C Q31: C Q32: B Q33: A Q34: C Q35: C Q36: B Q37: D

Q38: B Q39: B Q40: B