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# NATIONAL LEVEL SCIENCE TALENT SEARCH EXAMINATION (UPDATED)

***CLASS - 12 (PCB)***

***Question Paper Code : UN487***

## KEY

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. C | 2. C | 3. B | 4. D | 5. C | 6. A | 7. A | 8. D | 9. C | 10. B |
| 11. C | 12. C | 13. B | 14. A | 15. C | 16. B | 17. C | 18. B | 19. D | 20. C |
| 21. D | 22. B | 23. B | 24. D | 25. D | 26. C | 27. A | 28. C | 29. C | 30. C |
| 31. B | 32. A | 33. C | 34. D | 35. D | 36. C | 37. A | 38. B | 39. A | 40. A |
| 41. B | 42. D | 43. C | 44. A | 45. D | 46. C | 47. A | 48. B | 49. B | 50. D |
| 51. A | 52. B | 53. B | 54. A | 55. D | 56. A | 57. A | 58. A | 59. B | 60. D |

## SOLUTIONS

### BIOLOGY

01. (C) A and B explain why such insecticides remain in the bodies of consumers that happen to take in polluted water or feed on contaminated prey. D explain why such insecticides persist for a long time in the environment, thus increasing the likelihood of contaminating living organisms in the ecosystem. C is false because such insecticides are non-biodegradable and unlikely to be viable food sources.

02. (C) Feeding directly on producers would drastically shorten the food chain. Shorter food chains are more efficient than long food chains as they allow more energy to be available to the final consumers since less energy is lost to the environment during energy transfers between trophic levels.

03. (B) Crossing over during prophase I of meiosis involves the exchange of DNA between non-sister chromatids of homologous chromosomes. This causes the chromatids involved in crossing over to contain new combinations of alleles

from both maternal and paternal origins. Eventually, this leads to increased variation among gametes formed from meiosis. A describes asexual reproduction, which produces genetically identical offspring. Mitosis does not lead to genetically variable daughter cells (C). A drastic change in environmental conditions would most likely kill off part of the population, causing a temporary decrease in variation (D).

04. (D) The most important reason for the fine cellular control of DNA replication and cell division is to prevent damage to chromosomes that could result in daughtr cells that bear mutations. Certain mutations may lead to the cell dividing uncontrollably, eventually leading to development of tumours and possibly cancer.

05. (C) Afflicted individuals are highly unlikely to pass the allele for the disease to subsequent generations since they die before they reach reproductive maturity (A and B). This being a genetic disease, cannot be transmitted by other means (D).

06. (A) A gene is a small unique segment of DNA on a particular chromosome where specific hereditary information is stored. While there are exceptions, genes are usually not repeated many times along a chromosome.

07. (A) Sister chromatids are two chromatids held together at the centromere. They are identical copies of each another (except after crossing over in meiosis), and each is a DNA double helix. Hence sister chromatids comprise a total of 2 DNA double helices (B). It is non-sister chromatids of a bivalent that exchange genetic material during crossing over, and not sister chromatids (C). Sister chromatids contain the same alleles of the same genes along their length since they are identical in terms of base sequence (D).

08. (D) GAC codes for Asp, CAC codes for His, and GUG codes for Val.

09. (C) Transcription occurs in the nucleu sbut translation in the cytoplasm (A). B is incorrect because whether a cell produces more RNA or protein depends on many factors, and it is not clear that either might occur at a higher frequency. Translation requires amino acids instead as raw materials to synthesise protein (D).

10. (B) tRNA serves as an adaptor molecule - matching correct amino acids to specific codons on mRNA at the ribosome. Translation occurs in the cytoplasm (A). C is incorrect since it does not directly address tRNA's role as an adaptor molecule. It is the ribosome that catalyses formation of peptide bonds (D).

11. (C) The effect of a gene or allele is known as the phenotype. Recessive alleles show their effect only in homozyygotes with two copies of the recessive allele. In a heterozygote with one dominant and recessive allele, it is the dominant phenotype that is expressed.

12. (C) 2 describes asexual reproduction, 3 describes growth and development of an individual organism and 4 describes tissue repair. All three processes require the production of new cells that are genetically identical to one another and the parent cell(s). Sperm cells, which are haploid gametes, are formed by meiosis from a diploid cell (1).

13. (B) A bivalent comprises two homologous chromosomes that have come together during synapsis in prophase 1 of meiosis. The two chromosomes undergo crossing over. Each chromosome comprises a pair of sister chromatids, thus a bivalent contains a total of four chromatids (A). Any two chromosomes could line up next to each other during metaphase; they need not be homologous (C). Chromosomes that are being pulled apart cannot possibly be considered bivalents (D).

14. (A) Meiosis is necessary for sexual reproduction to occur.

15. (C) Fatigue, hormonal imbalances and dietary deficiencies causes variation in menstrual cycle.

16. (B) An ovum is first released from an ovary in the process of ovulation. The ovum might be fertilised by a sperm, forming a zygote that divides into a ball of cells known as an embryo. The embryo is implanted into the wall of the uterus, and develops into a fetus which is eventually delivered from the uterus at birth.

17. (C) The umbilical cord in humans contain two umbilical arteries and one umbilical vein.

18. (B) Anthers produce pollen grains.

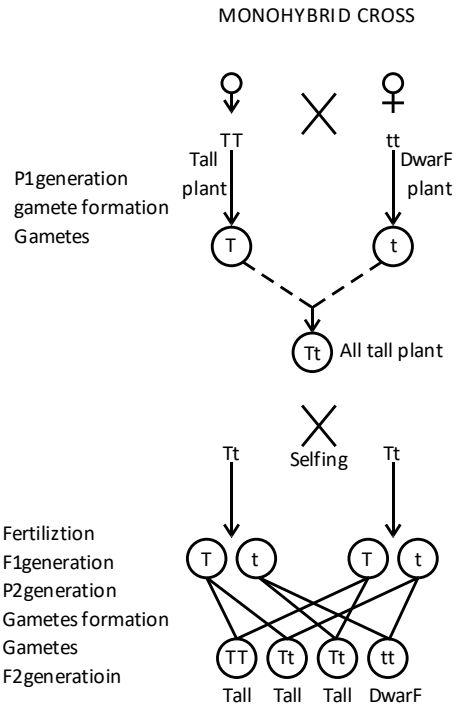
19. (D) Emulsification of fat is a physical reaction involving bile which does not contain any enzymes. A and B are enzymatic reactions involving trypsin and rennin respectively. The digestion of cellulose by bacteria occurs in the gut of many organisms and the bacteria do so by producing cellulase.

20. (C) Pomato was produced by fusion of potato and tomato protoplasts through somatic hybridization technique.

21. (D) Fallopian tube is a part of female reproductive system, the other three are the parts of male reproductive system.

22. (B) Very little yolk in oligolecithal egg facilitates total holoblastic cleavage.

23. (B) Each parent produces two types of gametes.




24. (D) Base analogues are certain substances having moleculear structure similar to using DNA bases.

25. (D) Because synergid is a haploid cell. Thus, if root cell has 2n = 42, synergids will have n = 21.

## PHYSICS

26. (C) $R_1 = R,\ R_2 = 2R,\ t_1 = 20°\ C,\ t_2 = ?$

$\alpha = 3.8 \times 10^{-3}\ °C^{-1},\ \alpha = \dfrac{R_2 - R_1}{R_1 t_2 - R_2 t_1}$

$3.8 \times 10^{-3} = \dfrac{2R - R}{Rt_2 - 2R \times 20};$

$Rt^2 - 40R = \dfrac{R}{3.8 \times 10^{-3}}$

$t_2 = \dfrac{1000}{3.8} + 40 = 303°\ C$

27. (A) $E = 100 \cos 100\ t$ volt

$E_0 = 100$ V, $\omega = 100$ rad/s

$R = 10\ \Omega$, $L = 100$ mH $= 10^{-1}$ H

$\tan\phi = \dfrac{X_L}{R} = \dfrac{\omega L}{R} = \dfrac{100 \times 10^{-1}}{10} = 1$

$\phi = \dfrac{\pi}{4}$

28. (C) Inside a magnet, its magnetic lines of force move from south pole of a magnet towards its north pole.

29. (C) Here, $\vec{E} = 2 \times 10^3\ \hat{k}$ V/m

$\vec{ds} = (10 \times 20) \times 10^{-4}\ \hat{k} m^2$

$d\phi = \vec{E} \cdot \vec{ds} = 2 \times 10^3 \hat{k} \cdot (10 \times 20 \times 10^{-4}) \hat{k}$

$= 40$ V-m

30. (C) In hydrogen atom, $E_n = -\dfrac{Rhc}{n^2}$

Also, $E_n \propto$ m, where m is the mass of the electron.

Here, the electron has been replaced by a particle, whose mass is double the mass of an electron. Therefore, for this hypothetical atom, energy in nth orbit will be given by,

$E_n = -\dfrac{2Rhc}{n^2}$

The longest wavelength (or minimum energy) photon will correspond to the transition of particle from n = 3 to n = 2

$\Rightarrow \dfrac{hc}{\lambda_{max}} = E_3 - E_2 = 2Rhc\left[\dfrac{1}{2^2} - \dfrac{1}{3^2}\right]$

$= 2\ R\ hc \times \dfrac{5}{36}$

$\therefore \lambda_{max} = \dfrac{hc}{\frac{5}{18}Rhc} = \dfrac{18}{5R}$

31. (B) $n = \dfrac{150}{30 \times 10^{-2}} = 500$ turns/m

Total length of the copper wire = L = 2 $\pi rnl$ where $l$ is the length of the solenoid and r its radius

$l = 0.30$ m, $r = 0.03$ m

$L = 2 \times 3.14 \times 0.03 \times 500 \times 0.30 = 28.26$ m

Resistance of the wire

$= R = 0.01 \times 28.26 = 0.2826\ \Omega$

Current = $I = \dfrac{V}{R} = \dfrac{12}{0.2826} = 42.46$ A

$B = \mu_0 nl = 4\pi \times 10^{-7} \times 500 \times 42.46$

$= 0.027$ T

32. (A) The critical angle for total internal reflection is computed as follows:

$\sin\theta_c = \dfrac{n_2}{n_1} = \dfrac{1.45}{2.90} = \dfrac{1}{2} \Rightarrow \theta_c = 30°$

Total internal reflection can be happen only if the incident beam originates in the medium with the higher index of refraction and strikes teh interface of the other medium at an angle of incidence greater than the critical angle.

33. (C) No. of half lives, $n_1 = \dfrac{80}{20} = 4$

$n_2 = \dfrac{80}{40} = 2$

$\dfrac{N_1}{N_0} = \left(\dfrac{1}{2}\right)^{n_1} = \left(\dfrac{1}{2}\right)^4 = \dfrac{1}{16}$

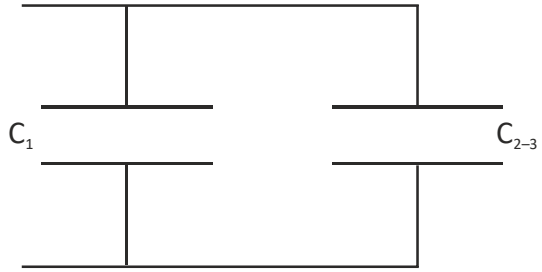
$$\frac{N_2}{N_0}=\left(\frac{1}{2}\right)^{n_2}=\left(\frac{1}{2}\right)^2=\frac{1}{4}$$

$$\frac{N_1}{N_2}=\frac{1}{16}\times\frac{4}{1}=\frac{1}{4}$$

34. (D) From the "crossed" position, Nicol-prism is rotated through 60°. Therefore, angle between two Nicols-prisms will be 30°.

$$\therefore \quad I=I_0\cos^2 30^\circ=\frac{3}{4}I_0=75\%\text{ of }I_0$$

35. (D) Observe that $C_2$ and $C_3$ are in series, and they are in parallel with $C_1$. That is the capacitor equivalent to the series combination of $C_2$ and $C_3$ (which we'll call $C_{2-3}$) is in parallel with $C_1$. We can represent this as follows:




So, the first step is to find $C_{2-3}$:

$$\frac{1}{C_{2-3}}=\frac{1}{C_2}+\frac{1}{C_3}\Rightarrow C_{2-3}=\frac{C_2C_3}{C_2+C_3}$$

Now this is in parallel with $C_1$, so the overall equivalent capacitance ($C_{1-2-3}$) is

$$C_{1-2-3}=C_1+C_{2-3}=C_1+\frac{C_2C_3}{C_2+C_3}$$

Substituting in the given numerical values, we get,

$$C_{1-2-3}=(2\,\mu F)+\frac{(4\,\mu F)(6\,\mu F)}{(4\,\mu F)+(6\,\mu F)}=4.4\,\mu F$$

36. (C) Frequency of electromagnetic wave does not change win change in medium for a ray of light but wavelength of wave with change in medium.

$$\nu_{vacuum}=\frac{1}{\sqrt{\mu_0\in_0}}=\nu\lambda_0 \text{ and in medium}$$

$$\nu_{med}=\nu\lambda_m=\frac{1}{\sqrt{\mu_0\mu\in_0\in_r}}$$

$$\text{or}\quad \nu\lambda_m=\frac{\nu}{\sqrt{\in_r}}=\frac{\nu}{\sqrt{4}}=\frac{\nu}{2}$$

$$\therefore \quad \frac{\lambda_m}{\lambda_0}=\frac{1}{2}\text{ or }\lambda_m=\frac{\lambda_0}{2}$$

37. (A) Max. K.E. = $h\nu - \phi_0$

$= 6.63\times10^{-34}\times8\times10^{14}-3.2\times10^{-19}$

$= 2.1\times10^{-19}$ J.

38. (B) The coil of a moving coil galvanometer is wound over a metal frame in order to provide electromagnetic damping by which the galvanometer becomes dead beat.

39. (A) For the curved surface, $\theta = 90^\circ$

$\therefore \quad \phi = E\,ds\cos 90^\circ = 0$

40. (A) Here, $A = 10\text{ cm}^2 = 10\times10^{-4}\text{ m}^2 = 10^{-3}\text{ m}^2$

$l = 20\text{ cm} = 0.2\text{ m}$, $n_1 = 300$, $n_2 = 400$, $M = ?$

$$M=\frac{\mu_0 n_1 n_2 A}{l}$$

$$=\frac{(4\pi\times10^{-7})\times300\times400\times10^{-3}}{0.2}$$

$= 2.4\pi\times10^{-4}$ H

## CHEMISTRY

41. (B) $Zn + Fe^{2+} \longrightarrow Zn^{2+} + Fe$ (n = 2)

$$E = E° - \frac{0.0591}{n}\log K_c$$

$$0.2905 = E° - \frac{0.0591}{2}\log\frac{0.01}{0.001}$$

or $E° = 0.2905 + 0.0295 = 0.32$ volt

$$E° = \frac{0.0591}{2}\log K_{eq}$$

$$0.32 = \frac{0.0591}{2}\log K_{eq}$$

$$K_{eq} = 10^{\frac{0.32}{0.0295}}$$

42. (D) $K_2Cr_2O_7 + 4\ KCl + 6\ H_2SO_4 \longrightarrow 2\ CrO_2Cl_2 + 6\ KHSO_4 + 3\ H_2O$

43. (C) $\underset{\text{Acetaldehyde (A)}}{CH_3CHO} \xrightarrow[\text{(ii) } H^+/H_2O]{\text{(i) } CH_3MgI} \underset{\text{Isopropyl alcohol (2°) (B)}}{CH_3-CHOH-CH_3}$

$\xrightarrow{\text{Victor Meyer's test}}$ Blue colour

44. (A) Half of the reaction is completed in 100 seconds

$\therefore$ $t_{1/2}$ = 100 sec.

$\therefore$ $K = \frac{0.693}{100}\text{sec}^{-1}$

For a first order reaction

$$K = \frac{2.303}{t}\log\frac{a}{a-x}$$

a = 100, x = 99, $t_{99\%}$ = ?

$$t_{99\%} = \frac{2.303}{K}\log\frac{100}{100-99}$$

$$= \frac{2.303\times100}{0.693}\log\ 100 \text{ sec.}$$

$$= \frac{2.303\times100\times\log 100 \text{ sec}}{0.693} = 664.64 \text{ sec.}$$

45. (D) The structural formula of the complex X is $[Cr(H_2O)_4Br_2]\ Cl.\ H_2O$, one mole of which gives 2 moles of particles $[Cr(H_2O)_5Cl]\ Br_2$, one mole of which gives 3 moles of particles $[Cr(H_2O)_5Cl]^{2+} + 2\ Br^-$

46. (C) $$\Delta T_f = \frac{1000\times K_f\times w_2}{w_1\times M_2}$$

$\Delta T_f$ (canesugar) = 273.15 – 271 = 2.15°

$\therefore$ $$2.15 = \frac{1000\times K_f\times 5}{95\times 342} \quad \text{..... (i)}$$

$$\Delta T_f(\text{Glucose}) = \frac{1000\times K_f\times 5}{95\times 180} \quad \text{..... (ii)}$$

Dividing (ii) by (i), we get,

$\frac{\Delta T_f(\text{Glucose})}{2.15} = \frac{342}{180}$ or $\Delta T_f$ (Glucose) = 4.08°

$\therefore$ Freezing point of glucose solution

= 273.15 – 4.08 = 269.07 K.

47. (A) As $C_3H_6O_2$ (B) on soda-lime distillation give $C_2H_6$ therefore, (B) must be a monocarboxylic acid. As (B) is obtained from (A) by loss of a molecule of $CO_2(C_4H_6O_4 - C_3H_6O_2)$, therefore, A must be a 1, 3-dicarboxylic acid in accordance with Blanc's rule. Thus, (A) most be $CH_3-CH(COOH)_2$ and (B) must be $CH_3CH_2COOH$.

48. (B) From 1 and 4, keeping [B] constant, [A] is made 4 times, rate also becomes 4 times. Hence rate $\propto$ [A].

From 2 and 3, keeping [A] constant, [B] is doubled, rate becomes 4 times. Hence, rate $\propto [B]^2$. Overall rate law will be : rate = k [A] $[B]^2$.

49. (B) $S_N1$ reaction does not involve inversion of configuration of the optically active substrate.

50. (D) In aq. sol, HCl dissociates but in benzene it does not.

51. (A) $\overset{+7}{KMnO_4} \longrightarrow \overset{+4}{MnO_2}$ ; $\overset{+7}{KMnO_4} \longrightarrow Mn^{2+}$

$\overset{+7}{KMnO_4} \longrightarrow \overset{+3}{Mn(OH)_3}$ ; $\overset{+7}{KMnO_4} \longrightarrow \overset{6+}{MnO_4^{2-}}$

52. (B)

$$CH_3-CH_2-CH_2-Br \xrightarrow[\text{(Dehydrobromination)}]{\text{Conc. alc. NaOH, 80°C (X)}} \underset{(-HBr)}{}$$

$$CH_3CH=CH_2 \xrightarrow[\text{(Mark. addition)}]{\text{HBr, acetic acid, 20°C (Y)}} CH_3-CHBr-CH_3$$

53. (B) For emf to be +ve, oxidation should occur at iron electrode.

$E_{cell} = 1.23 + 0.44\ V = 1.67\ V$

$\Delta G° = -nF\ E°cell = -2 \times 96500 \times 1.67\ J$

$= -322\ kJ$

54. (A) Molar mass of the complex, $H_{12}O_6Cl_3Cr = 266.5\ g\ mol^{-1}$

$P \xrightarrow{H_2SO_4\ (conc.)}$ No reaction

$Q \xrightarrow{H_2SO_4\ (conc.)}$ 6.75% loss in weight

$R \xrightarrow{H_2SO_4\ (conc.)}$ 13.5% loss in weight

Assuming the whole of H and O to be present as water ($H_2O$),

Mass of water in the compound = (12 + 96) g = 108 g

So, No. of molecules of water per molecule of the compound = $\frac{108\ g}{18\ g} = 6$

Then, Loss due to the loss of 1 $H_2O$ = $\frac{18\ g}{266.5\ g} \times 100$

= 6.75%

Loss due to the loss of 2 $H_2O$ molecules

= $\frac{2 \times 18}{266.5} \times 100$

= 13.50%

Thus, complexes Q and R lose one water molecule and two water molecules respectively when treated with concentrated $H_2SO_4$.

Thus, the formulae of P, Q and R are :

P : $[Cr(H_2O)_6]Cl_3$ - all molecules of water are present in the coordination sphere.

Q : $[Cr(H_2O)_5Cl]Cl_2.H_2O$ - five water molecules and one $Cl^-$ are present in the coordination sphere; one $H_2O$ molecule is loosely held by the compound.

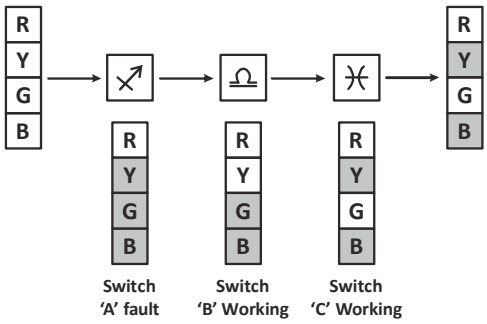
R : $[Cr(H_2O)_4Cl_2]Cl.2H_2O$ - four water molecules and two $Cl^-$ ions are present in the coordination sphere; two $H_2O$ molecules are loosely held by the compound.

55. (D) To produce R–CO–Ar, the acid chloride should be RCOCl and the hydrocarbon should be Ar–H, i.e.,

$$RCOCl + H-Ar \xrightarrow{AlCl_3} RCOAr + HCl$$

## CRITICAL THINKING

56. (A)




57. (A) "Humans can be violent towards animals"

The paragraph presents the following logic: A tiger has been spotted in the empty village.

It is no longer endangered by conflicts with humans.

The missing assumption here is that humans can be violent towards animals.

$\therefore$ Option (A) is correct

58. (A) 

59. (B) From II, we know that Kiran's mother is married to Janu's husband, which means that Janu is Kiran's mother.

60. (D) All the above statement are true regarding the context of the passage.

The End