# Biology

1. Match the following features to the animals. Which is the correct combination?

| | | |
|---|---|---|
| 1. Open circulatory system | 3. Earthworm | 5.Nephridia |
| 2. Closed circulatory system | 4. Malpighian tubules | 6. Cockroach |

A 1,3,4 and 2,5,6   B 1,4,6 and 2,3,5   C 1,3,5 and 2,4,6   D 1,5,6 and 2,3,4

2. Take two plants, keep plant A in very dry conditions and plant B in high humidity. Simultaneously, immerse the roots of both plants in water with a red dye. What would you observe?

A Plant A turns redder than Plant B.
B Plant B turns redder than Plant A.
C Neither plant turns red.
D Both plants turn equally red.

3. A population of finch birds with medium sized beaks colonizes an island with plants producing medium and large sized seeds. After a disease wipes out all the plants with medium sized seeds, what is most likely to happen to the finches?

A They will become extinct.
B Their beaks will not change at all.
C Their beaks become smaller.
D Their beaks will become larger.

4. If the population of a city of 100 people increases at an intrinsic rate of 0.1, but the city only has access to food and housing for 200 people, what will the current growth rate of the population be?

A 9/year   B Zero   C 2/year   D 5/year

5. Pick the INCORRECT statement regarding a mitochondrion,

A The inner and outer membranes have identical sets of enzymes.
B The mitochondrial matrix contains single circular DNA molecule.
C The inner membrane forms many infoldings called cristae.
D The mitochondrial matrix possesses 70S ribosomes.

6. Which of the following statements best describes the G0 stage of the cell cycle?

A Cells in this stage are dying.
B Cells in this stage are metabolically active but not dividing.
C Cells in this stage are highly proliferative.
D Cells in this stage are proliferative but metabolically inactive.

7. *Erythroblastosis foetalis* can be avoided by

A Administering anti−Rh antibodies to a Rh +ve woman before her first pregnancy.
B Administering anti−Rh antibodies to a Rh +ve mother after her first Rh +ve child birth.
C Administering anti−Rh antibodies to a Rh −ve woman before her first pregnancy.
D Administering anti−Rh antibodies to a Rh −ve mother after her first Rh +ve child birth.

8. During an oxidative phosphorylation the terminal electron acceptor is ———(fill up the blank)

A FAD   B $NAD^+$   C Oxygen   D Cytochrome C

9. Immature lymphocytes are primarily found in which one of the following organs?

A Peyer's Patches of small intestine   B Spleen   C Liver   D Thymus

10. If an enzyme reaction follows the Michaelis Menten kinetics represented by the equation:

$$V_0 = V_{max} \cdot \frac{[S]}{K_M + [S]}$$

where, $V_0$ is the initial reaction velocity, $V_{max}$ is the maximal reaction velocity, $K_M$ is the Michaelis constant and $[S]$ is the substrate concentration. Which of the following statements is correct?

A $K_M$ is the concentration of the enzyme at the optimal pH.

B $K_M$ is the reaction velocity at half the optimal substrate concentration.

C $K_M$ is the concentration of substrate when the velocity of the reaction is half that of the maximal velocity.

D $K_M$ is the concentration of the enzyme at the optimal temperature.

11. Common cold is mostly caused by Rhinoviruses. Which of the following treatments will provide the best cure from this infectious agent?

A A glass of Oral Rehydration Suspension (ORS) plus two tablets of streptomycin twice a day for three days.

B Two tablets of amoxycillin twice a day for at least three days.

C One tablet of amoxycillin plus one tablet of a pain killer four times a day for at least three days.

D Adequate rest and a balanced diet for at least three days.

12. In human females, when does oogenesis begin?

A At the time of puberty

B During embryonic development

C During ovulation

D At the time of birth

13. Which one of the following statements best defines properties of a compound epithelium?

A It is multilayered and mainly protects from chemical and mechanical stresses.

B It is multilayered and covers the outer lining of secretory glandular epithelium.

C It is multilayered and help binding tissues together and their eventual organization.

D It is multilayered and actively participates in secretion and absorption.

14. Which one of the following pairs of genotype and phenotype ratios will be obtained in F2 generation for Snapdragon plants exhibiting incomplete dominance for red and white flower color traits?

A 3:1 and 1:2:1 B 1:2:1 and 3:1 C 3:1 and 3:1 D 1:2:1 and 1:2:1

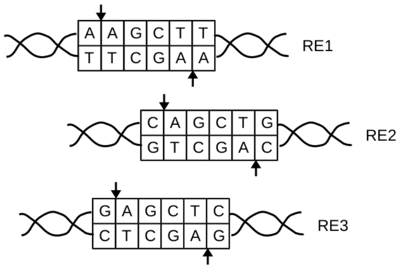
15. Provided below are recognition sequences for restriction enzymes 1 (RE1), 2 (RE2) and 3 (RE3). Arrows indicate the positions where the enzymes digest on the two strands. Which of the following can the RE1 digested DNA ligate to?

A All three RE1, RE2 and RE3 digested DNA.

B Only to RE1 digested DNA.

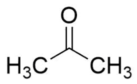
C Only to RE1 and RE3 digested DNA.

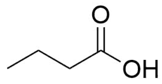
D Only to RE1 and RE2 digested DNA.

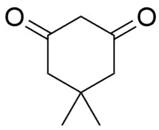


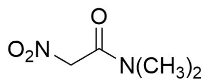
# Chemistry

16. In which one of the following cases will the $\alpha$−hydrogen NOT be abstracted on treatment with one equivalent of base?

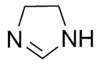
$\boxed{A}$ 

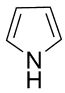
$\boxed{B}$ 

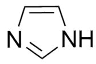
$\boxed{C}$ 

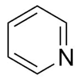
$\boxed{D}$ 

17. Arrange the following compounds in order of decreasing basicity.


(i)


(ii)


(iii)


(iv)

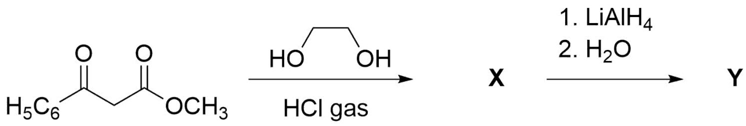
$\boxed{A}$ (i) > (iv) > (iii) > (ii)

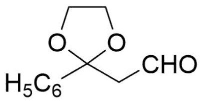
$\boxed{B}$ (iii) > (i) > (iv) > (ii)

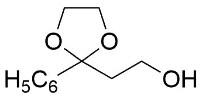
$\boxed{C}$ (i) > (iii) > (iv) > (ii)

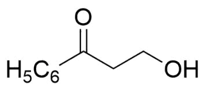
$\boxed{D}$ (ii) > (i) > (iii) > (iv)

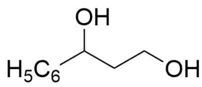
18. In the following reaction sequence, predict the structure of the final product **Y**.



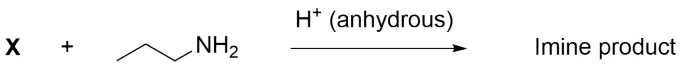

$\boxed{A}$ 

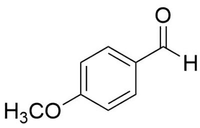
$\boxed{B}$ 

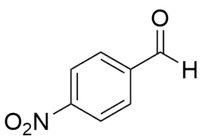
$\boxed{C}$ 

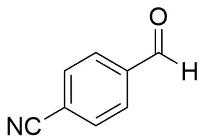
$\boxed{D}$ 

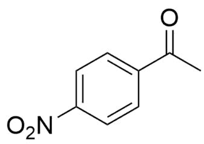
19. For the following reaction, identify the carbonyl compound **X** that shows the highest reactivity.




$\boxed{A}$ 

$\boxed{B}$ 

$\boxed{C}$ 

$\boxed{D}$ 

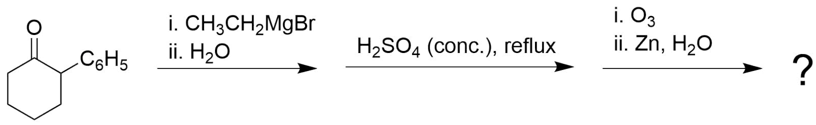
20. $SnCl_2$ dissolves in a solution containing $Cl^-$ ions to form $[SnCl_3]^-$. What would be the geometry of $[SnCl_3]^-$ ?

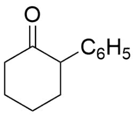
$\boxed{A}$ Trigonal planar $\boxed{B}$ T-shaped $\boxed{C}$ Trigonal pyramidal $\boxed{D}$ Tetrahedral

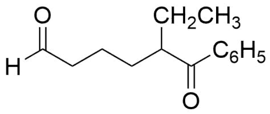
21. How many nodes are there in the antibonding molecular orbital formed by two 2$s$ atomic orbitals?

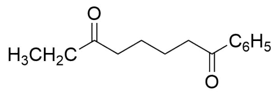
$\boxed{A}$ 1 $\boxed{B}$ 2 $\boxed{C}$ 0 $\boxed{D}$ 3

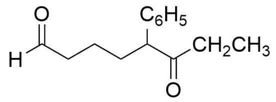
22. Identify the major product in the following reaction



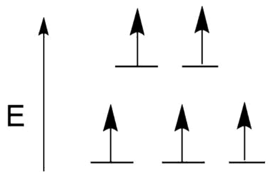

A 


B 


C 


D 


23. A complex of metal $M^{n+}$ has the following electronic distribution in $d$ orbitals,




The neutral M has a ground state electronic configuration of $[Ar]4s^2 3d^6$. Which of the following complexes is consistent with the electronic distribution of $M^{n+}$ (as described above)?

A $[M(CN)_6]^{4-}$  B $[MF_6]^{3-}$  C $[MF_6]^{4-}$  D $[M(CN)_6]^{3-}$

24. Identify the complex that can exist as a pair of enantiomers.

A $[Co(H_2NCH_2CH_2NH_2)_3]^{3+}$
B *trans*–$[Co(H_2NCH_2CH_2NH_2)_2Cl_2]^+$
C $[Co(NH_3)_4Cl_2]^+$
D $[Co\{P(C_2H_5)_3\}_2ClBr]$

25. Which of the following complexes is expected to be colored?

A $[Al(H_2O)_6]^{3+}$  B $[Zn(H_2O)_6]^{2+}$  C $[Ni(H_2O)_6]^{2+}$  D $[Mg(H_2O)_6]^{2+}$

26. Density of 3M solution of NaCl is 1.25 $g/mL$. Calculate the volume of water required to make 1000 $mL$ of this NaCl solution. [Consider the density of water as 1 $g/mL$].

A 1074.5 $mL$  B 824.5 $mL$  C 1250 $mL$  D 1000 $mL$

27. Electric current was passed through an aqueous solution of $CuSO_4$ using two Pt electrodes. After some time, the blue color of the solution disappeared along with evolution of $O_2$ gas. Which of the following statements is correct regarding the resultant solution?

A $[Cu^{2+}] > [SO_4^{2-}]$  B pH $< 7$  C pH $> 7$  D $[Cu^{2+}] = [SO_4^{2-}]$

28. Reactant $R$ gives $n$ different products ($P_r : r = 1, 2, 3, \cdots, n$) in $n$ parallel first order reactions. Rate constant for the formation of any product $P_r$ is $rk$ where $r = 1, 2, 3, \cdots, n$. For the decay of $R$, what is the overall rate constant in terms of $k$?

A $nk$  B $\frac{n(n+1)k}{2}$  C $k$  D $e^{-nk}$

29. Consider a hypothetical case in which the charge of a proton is twice as that of an electron. Using this hypothetical case, how many protons (P), neutrons (N) and electrons (E) would a neutral $^{23}$Na atom contain?

A P = 12, N = 11, E = 23

B P = 11, N = 12, E = 23

C P = 11, N = 12, E = 11

D P = 11, N = 12, E = 22

30. The magnitude of reversible work done by an ideal gas in four different processes: isothermal expansion, adiabatic expansion, constant pressure expansion, and free expansion are $W_i$, $W_a$, $W_p$, and $W_f$ respectively. Choose the right order of sequence for the magnitude of the work done. (Change in the volume is same for all the processes.)

A $W_i > W_p > W_a > W_f$

B $W_p > W_i > W_a > W_f$

C $W_i > W_p > W_f > W_a$

D $W_p > W_a > W_i > W_f$

# Mathematics

31. The number of solutions of the equation $2\sin^2 x + 1 = 3\sin x$ in the interval $(0, \pi)$ is

$\boxed{A}$ 0. $\boxed{B}$ 2. $\boxed{C}$ 1. $\boxed{D}$ 3.

32. For $n \geq 2$, the number of onto functions from the set $\{1, 2, \ldots, n\}$ to the set $\{1, 2\}$ is

$\boxed{A}$ $2^n$. $\boxed{B}$ $2^n - 2$. $\boxed{C}$ $n!$. $\boxed{D}$ $2^n - 1$.

33. Let $f : \mathbf{R} \to \mathbf{R}$ be a differentiable function such that $f'(0) = 1$ and

$$f(x+y) = f(x)f(y) \text{ for all } x,\, y \in \mathbf{R}.$$

Which of the following is true?

$\boxed{A}$ $f$ is a decreasing function but $f'$ is an increasing function.
$\boxed{B}$ Both $f$ and $f'$ are increasing functions.
$\boxed{C}$ $f$ is an increasing function but $f'$ is a decreasing function.
$\boxed{D}$ Both $f$ and $f'$ are decreasing functions.

34. The number of points of intersection of the curves $x^2 + 8y^2 = 4$ and $x^2 + y^2 = 1$ is

$\boxed{A}$ 0. $\boxed{B}$ 4. $\boxed{C}$ 1. $\boxed{D}$ 2.

35. The coefficient of $x^9$ in $\left(x^2 - \frac{1}{3x}\right)^9$ is

$\boxed{A}$ $-3$. $\boxed{B}$ $-\frac{56}{9}$. $\boxed{C}$ $-\frac{28}{9}$. $\boxed{D}$ $\frac{28}{9}$.

36. The roots of the polynomial $x^3 - 39x^2 + 471x - 1729$ are in an arithmetic progression. Which of the following is a common difference of the progression?

$\boxed{A}$ 6 $\boxed{B}$ 19 $\boxed{C}$ 13 $\boxed{D}$ 7

37. Let $f : \mathbf{R} \to \mathbf{R}$ be defined as

$$f(x) = \begin{cases} \frac{e^{3x} - e^{x} - e^{2x} + 1}{x^2} & \text{if } x > 0, \\ a & \text{if } x = 0, \\ \frac{1 - \cos(2x)}{x^2} & \text{if } x < 0. \end{cases}$$

The value of $a$ for which $f$ is continuous at 0 is

$\boxed{A}$ 1. $\boxed{B}$ 2. $\boxed{C}$ 0. $\boxed{D}$ 3.

38. Let $S$ be a set with 3 elements. What is the probability of choosing an ordered pair $(A, B)$ of subsets of $S$ such that $A$ and $B$ are disjoint?

$\boxed{A}$ $\frac{1}{2}$ $\boxed{B}$ $\frac{26}{64}$ $\boxed{C}$ $\frac{27}{64}$ $\boxed{D}$ $\frac{1}{8}$

39. Consider the functions $y_1$ and $y_2$ satisfying

$$\frac{dy_1}{dx} = -y_2,\ \frac{dy_2}{dx} = y_1,\ y_1(0) = 1,\ y_2(0) = 0.$$

The set $S = \{(y_1(x), y_2(x)) : x \in \mathbf{R}\}$ lies on a

$\boxed{A}$ hyperbola. $\boxed{B}$ straight line. $\boxed{C}$ circle. $\boxed{D}$ parabola.

40. A function $f$ satisfying $f \circ f \circ f(x) = x$ for all $x \in \mathbf{R}$ is

$\boxed{\text{A}}$ onto but not one–one.

$\boxed{\text{B}}$ neither one–one nor onto.

$\boxed{\text{C}}$ one–one and onto.

$\boxed{\text{D}}$ one–one but not onto.

41. The function $f(x) = \sin x + \frac{1}{\sin x}$ in the interval $(0, \pi)$ has a

$\boxed{\text{A}}$ local minima at $\pi/2$.

$\boxed{\text{B}}$ local maxima at $\pi/3$.

$\boxed{\text{C}}$ local minima at $\pi/6$.

$\boxed{\text{D}}$ local maxima at $\pi/4$.

42. Let $p$ be a polynomial with real coefficients such that $\int_0^1 p(t)dt = 0$. Which of the following statements is always true?

$\boxed{\text{A}}$ $p$ has no roots in the interval $[0, 1]$.

$\boxed{\text{B}}$ All roots of $p$ lie in the interval $[0, 1]$.

$\boxed{\text{C}}$ $p$ has exactly one root in the interval $[0, 1]$.

$\boxed{\text{D}}$ $p$ has a root in the interval $[0, 1]$.

43. For a complex number $z$, let $(1+z)^{15} = a_0 + a_1 z + \cdots + a_{15} z^{15}$. The value of

$$(a_0 - 4a_2 + 16a_4 + \cdots - 2^{14}a_{14})^2 + (2a_1 - 8a_3 + 32a_5 \cdots - 2^{15}a_{15})^2$$

is

$\boxed{\text{A}}$ $2^{30}$. $\boxed{\text{B}}$ $2^{15}$. $\boxed{\text{C}}$ 1. $\boxed{\text{D}}$ $5^{15}$.

44. Let $A$ be a $3 \times 3$ matrix which has determinant 3 and satisfies the equation $A^2 - 7A + 4I = 0$. The value of $|\det\,(A - 2I)|$ is

$\boxed{\text{A}}$ 5. $\boxed{\text{B}}$ 1. $\boxed{\text{C}}$ 3. $\boxed{\text{D}}$ 9.

45. Consider the functions

$$g(x) = \begin{cases} 1 & \text{if } x \in [-1, 1], \\ 0 & \text{otherwise} \end{cases}$$

and

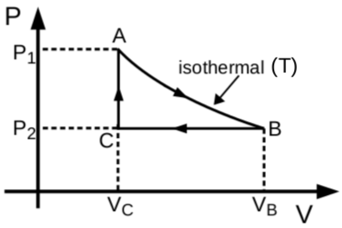
$$f(x) = \lim_{h \to 0} \frac{1}{2h} \int_{x-h}^{x+h} g(y)dy.$$

The value of $f(1)$ is

$\boxed{\text{A}}$ 1/2. $\boxed{\text{B}}$ $-1$. $\boxed{\text{C}}$ 1. $\boxed{\text{D}}$ 0.

# Physics

46. One mole of an ideal gas is taken around the complete cycle as shown in the PV-diagram. Considering the universal gas constant R, the work done by the gas in one complete cycle is




A $\mathrm{R}T\ln\frac{V_B-V_C}{V_C}$.

B $(P_1-P_2)V_C+P_2(V_B-V_C)$.

C $\mathrm{R}T\ln\frac{V_B}{V_C}-P_2(V_B-V_C)$.

D 0.

47. A Copper wire of length $L_{\mathrm{Cu}}$, Young's modulus $Y_{\mathrm{Cu}}$, and diameter $d$ is hung from the ceiling. An Aluminium wire of length $L_{\mathrm{Al}}$, Young's modulus $Y_{\mathrm{Al}}$, and of same diameter $d$ is joined end−to−end at the free end of the Copper wire. If under the action of a load applied at the free end of the Aluminium wire the net elongation is $\Delta L$, the applied load is

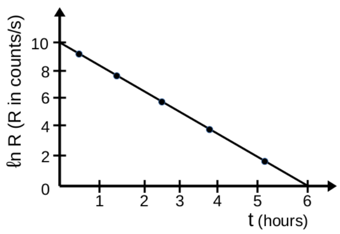
A $\frac{\pi d^2\Delta L(Y_{\mathrm{Cu}}L_{\mathrm{Al}}-Y_{\mathrm{Al}}L_{\mathrm{Cu}})}{4L_{\mathrm{Cu}}L_{\mathrm{Al}}}$.

B $\frac{\pi d^2\Delta L(Y_{\mathrm{Cu}}L_{\mathrm{Al}}+Y_{\mathrm{Al}}L_{\mathrm{Cu}})}{4L_{\mathrm{Cu}}L_{\mathrm{Al}}}$.

C $\frac{\pi d^2 Y_{\mathrm{Cu}}Y_{\mathrm{Al}}\Delta L}{4(Y_{\mathrm{Cu}}L_{\mathrm{Al}}+Y_{\mathrm{Al}}L_{\mathrm{Cu}})}$.

D $\frac{\pi d^2 Y_{\mathrm{Cu}}Y_{\mathrm{Al}}\Delta L}{4(Y_{\mathrm{Cu}}L_{\mathrm{Al}}-Y_{\mathrm{Al}}L_{\mathrm{Cu}})}$.

48. From the given plot of the decay rate R versus time $t$ of some radioactive nuclei, the half life of the nuclei in hours can be estimated to be




A 2.5. B 3. C $\frac{3}{5}\ln 2$. D $\frac{5}{3}\ln 2$.

49. A particle of mass $m_1$ and velocity $\vec{v_i}$ collides head-on with a stationary particle of mass $m_2$. After collision the velocity of both particles is $\vec{v_f}$. The energy lost in the collision is

A $\frac{1}{2}m_1v_i^2[1-\frac{m_1}{m_1+m_2}]$.

B $\frac{1}{2}m_2v_i^2[1-\frac{m_1}{m_1+m_2}]$.

C $\frac{1}{2}(m_1+m_2)(v_i-v_f)^2$.

D $\frac{1}{2}m_1v_i^2[1-\frac{m_2}{m_1+m_2}]$.

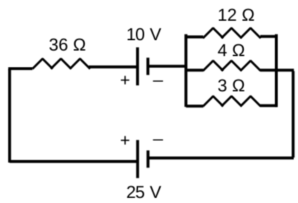
50. Particles of mass $m_1$ and $m_2$ initially sitting at the same position, start moving simultaneously at $t=0$ with velocities $\vec{v_1}$ and $\vec{v_2}$, respectively. After a time $t=t_0$ the angular momentum of the particle of mass $m_2$ with respect to the particle of mass $m_1$ is

A $|\vec{v_1}-\vec{v_2}|^2\frac{m_1m_2}{m_1+m_2}t_0$. B $|\vec{v_1}-\vec{v_2}|^2\frac{m_2^2}{m_1}t_0$. C $|\vec{v_1}-\vec{v_2}|^2m_2t_0$. D 0.

51. If the refractive index of the material of a prism is $\mu$ and its angle of minimum deviation is $\pi/3$ then the angle of the prism is

A $2\cot^{-1}(\frac{1-2\mu}{\sqrt{3}})$. B $2\cot^{-1}(\frac{2\mu-1}{\sqrt{3}})$. C $2\cot^{-1}(\sqrt{3}-2\mu)$. D $2\cot^{-1}(2\mu-\sqrt{3})$.

52. The current through the 36 Ω resistor in the given circuit is

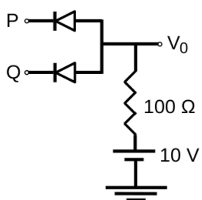



A 2/5 A B 1/3 A C 2/3 A D 70/75 A

53. The dimension of $1/RC$, where $R$ is the resistance and $C$ is the capacitance, is the same as that of

A Current. B Charge. C Frequency. D Time.

54. In the given circuit, the input voltages at P and Q could be either 0 V or 10 V. Use the fact that a diode under forward bias is a short circuit, and under reverse bias is an open circuit. The truth table of the circuit will be that of



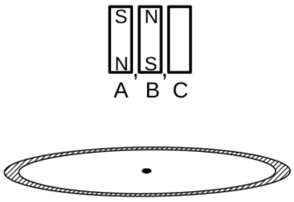

$\boxed{A}$ an AND Gate. $\boxed{C}$ a NAND Gate.

$\boxed{B}$ an OR Gate. $\boxed{D}$ a NOR Gate.

55. What should be the closest approximate radius of a celestial body twice as massive as the sun so that the escape speed from the celestial body is equal to the speed of light? (The mass of sun is $2 \times 10^{30}$ Kg, speed of light is $3 \times 10^8$ m/s, and universal gravitational constant $G = 7 \times 10^{-11}$ N m$^2$/Kg$^2$.)

$\boxed{A}$ 300 km $\boxed{B}$ 90 km $\boxed{C}$ 6 km $\boxed{D}$ 1 km

56. Two bar magnets A and B, and a non-magnetic bar C, all of same mass and dimensions, are dropped in an identical manner one by one through the center of a copper loop held horizontally (as shown in the figure). The times taken by the bars A, B, and C to reach the ground are $t_A$, $t_B$, and $t_C$, respectively. Which of the following relations is correct?



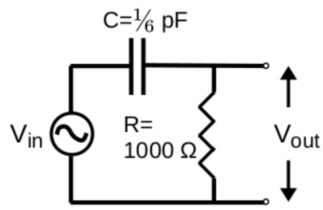

$\boxed{A}$ $t_A > t_B > t_C$ $\boxed{C}$ $t_A = t_B < t_C$

$\boxed{B}$ $t_A = t_B > t_C$ $\boxed{D}$ $t_A < t_B < t_C$

57. A metal, whose temperature coefficient of resistivity is $5{\times}10^{-4}\ {}^oC^{-1}$, is heated from 100 $^o$C to 1100 $^o$C. By what factor does the mobility of electrons in the metal change due to this change in temperature?

$\boxed{A}$ $3/2$ $\boxed{B}$ $\sqrt{3}/2$ $\boxed{C}$ $\sqrt{2}$ $\boxed{D}$ $2/3$

58. In the given circuit, what is the closest approximate frequency at which the ratio $V_{out}/V_{in}$ is $1/\sqrt{2}$?




$\boxed{A}$ $0.16 \times 10^6$ Hz $\boxed{C}$ $10^9$ Hz

$\boxed{B}$ $1.6 \times 10^6$ Hz $\boxed{D}$ $10^6$ Hz

59. The transverse displacement at position $x$ and time $t$ in a string due to a travelling wave is given by $y(x,t) = 3.0\cos(\pi x - 4\pi t)$ cm, where $x$ is in centimeters and $t$ is in seconds. Which of the following statements is wrong?

$\boxed{A}$ Maximum value of transverse velocity of any point is $12\pi$ cm/s and wavelength is 0.2 m.

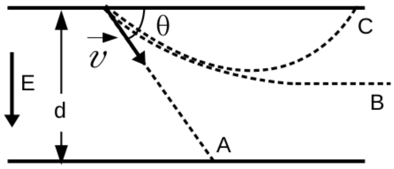
$\boxed{B}$ Speed of wave propagation in the +ve $x$-direction is $4\pi$ cm/s.

$\boxed{C}$ Transverse velocity at $t = 0$ and $x = 0.25$ cm is $6\sqrt{2}\pi$ cm/s.

$\boxed{D}$ Maximum value of transverse acceleration of any point is $48\pi^2$ cm/s$^2$.

60. An electron of mass $m_e$ and charge $e$ is projected with a speed $v$ making an angle $\theta$ with respect to the top electrode of a parallel plate capacitor as shown in the figure. Considering only the effect of the downward constant electric field $E$ on the electron's motion, which of the following statements is correct.

$\boxed{A}$ Electron moves along trajectory C with a time of flight given by $(m_e v/eE)\sin^2\theta$.




$\boxed{B}$ Electron moves along trajectory C with a maximum horizontal displacement given by $(m_e v^2 \sin 2\theta)/eE$.

$\boxed{C}$ Electron moves along trajectory A with a horizontal displacement given by $v\cos\theta\sqrt{2dm_e/eE}$.

$\boxed{D}$ Electron moves along trajectory B with a final velocity $v\cos\theta$ parallel to the electrodes.