01/02/2023
Evening

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Memory Based
Answers & Solutions

Time : 3 hrs. *for* M.M. : 300

JEE (Main)-2023 (Online) Phase-1

(Physics, Chemistry and Mathematics)

IMPORTANT INSTRUCTIONS:

(1) The test is of **3 hours** duration.

(2) The Test Booklet consists of 90 questions. The maximum marks are 300.

(3) There are **three** parts in the question paper consisting of **Physics, Chemistry** and **Mathematics** having 30 questions in each part of equal weightage. Each part (subject) has two sections.

(i) **Section-A:** This section contains 20 multiple choice questions which have only one correct answer. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer.

(ii) **Section-B:** This section contains 10 questions. In Section-B, attempt any **five questions out of 10.** The answer to each of the questions is a numerical value. Each question carries **4 marks** for correct answer and **–1 mark** for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. Ratio of acceleration due to gravity on the surface of planet 1 and planet 2 is x while the ratio of radii of respective planets is y. The ratio of respective escape velocities on the surface of planet 1 and planet 2 is equal to

(1) $\frac{\sqrt{x}}{y}$ (2) $\frac{x}{y}$

(3) $\sqrt{xy}$ (4) xy

Answer (3)

Sol. $v_e = \sqrt{2\frac{GM}{R}\times\frac{R}{R}} = \sqrt{2gR}$

So, $\frac{v_1}{v_2} = \sqrt{\frac{g_1}{g_2}\frac{R_1}{R_2}} = \sqrt{xy}$

2. In a hydrogen atom, an electron makes a transition from 3rd excited state to ground state. Find the energy of the photon emitted.

(1) 10.8 eV (2) 13.6 eV

(3) 12.75 eV (4) 8.6 eV

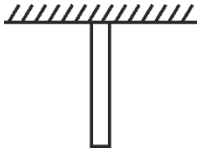
Answer (3)

Sol. $\Delta E = 13.6(1)^2\left[1-\frac{1}{4^2}\right]\text{eV}$

$= 13.6\times\frac{15}{16}\text{ eV}$

= 12.75 eV

3. A uniform rod of mass 10 kg and length 6 m is hanged from the ceiling as shown. Given area of cross-section of rod 3 mm^2 and Young's modulus is 2×10^{11} N/m^2. Find extension in the rod's length. (use g = 10 m/s^2)

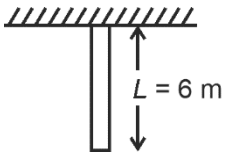


(1) 1 mm (2) 0.5 mm

(3) 0.25 mm (4) 1.2 mm

Answer (2)

Sol.



$Y = 2 \times 10^{11}$ (N/m^2)

A = 3 mm^2

Mass of rod = 10 kg

$\Delta L = \left(\frac{mgL}{2AY}\right) = \frac{10\times10\times6}{2\times3\times10^{-6}\times2\times10^{11}}$

$= \frac{1}{2}\times10^{-3}$ m

= 0.5 mm

4. For a heat engine based on carnot cycle source is at temperature 600 K. Now if source temperature is doubled then efficiency also gets doubled while keeping the sink temperature same at x kelvin. Value of x is equal to

(1) 400 K (2) 600 K

(3) 200 K (4) 300 K

Answer (1)

Sol. Let initially efficiency is x and sink temperature is T thus.

$x = 1-\frac{T}{600}$

$2x = 1-\frac{T}{1200}$

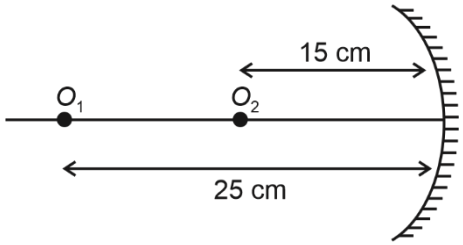
$\frac{1}{2} = \frac{1-T/600}{1-T/1200}$

$\frac{1}{2}-\frac{T}{2400} = 1-\frac{T}{600}$

$\frac{T}{800} = \frac{1}{2}$

T = 400 K

5. Two point objects O_1 and O_2 are placed on principal axis of concave mirror of radius of curvature 40 cm. Find the distance between the two images

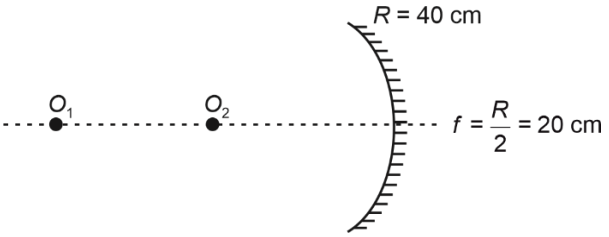


(1) 160 cm (2) 40 cm

(3) 100 cm (4) 80 cm

Answer (1)

Sol.



For O_1

$u = -25$ cm

$f = -20$ cm

$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}$

$\Rightarrow \frac{1}{v_1}=\frac{1}{f}-\frac{1}{u}=\frac{-1}{20}+\frac{1}{25}=\frac{-5+4}{100}=\frac{-1}{100}$

$v_1 = -100$ cm

For O_2

$u = -15$ cm

$f = -20$ cm

$\frac{1}{v_2}=\frac{-1}{20}+\frac{1}{15}$

$=\frac{-3+4}{60}=\frac{-1}{60}$

$v_2 = +60$

$|v_1 - v_2| = [60 - (-100)] = 160$ cm

6. For a photoelectric setup, threshold frequency is f_0. For incident frequency of $2f_0$, stopping potential is V_1 & for incident frequency of $5f_0$, stopping potential is V_2. Find $\frac{V_1}{V_2}$

(1) 1/5

(2) 1/2

(3) 1/3

(4) 1/4

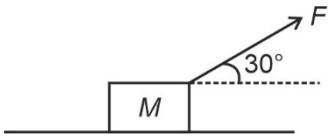
Answer (4)

Sol. $eV_1 = h(2f_0) - hf_0$

$eV_2 = h(5f_0) - hf_0$

$\Rightarrow \frac{V_1}{V_2}=\frac{f_0}{4f_0}=\frac{1}{4}$

7. A block is acted upon by a force F as shown:



If $M = 10$ kg and coefficient of friction is 0.25, find minimum F so that block slides

(1) $\frac{200}{4\sqrt{3}+1}$N

(2) $\frac{200}{4\sqrt{3}-1}$N

(3) $\frac{100}{4\sqrt{3}+1}$N

(4) 50 N

Answer (1)

Sol. $F\sin30° + N = Mg$ ...(1)

$F\cos30° = \mu N$ ...(2)

$\Rightarrow F=\frac{200}{4\sqrt{3}+1}$N

8. If universal gravitational constant (G), Plank's constant (h) and speed of light (c) are taken as fundamental quantities then dimensions of mass are equal to

(1) $\sqrt{\frac{Gh}{c}}$

(2) $\sqrt{\frac{G}{hc}}$

(3) $\sqrt{\frac{h}{Gc}}$

(4) $\sqrt{\frac{hc}{G}}$

Answer (4)

Sol. $[m] = [G]^x [h]^y [c]^z$

$[m] = [M^{-1}L^3T^{-2}]^x [ML^2T^{-1}]^y [LT^{-1}]^z$

$\Rightarrow y - x = 1$ ...(1)

$3x + 2y + z = 0$ ...(2)

$-2x - y - z = 0$ ...(3)

On solving $x=-\frac{1}{2}, y=\frac{1}{2}, z=\frac{1}{2}$

So $m=\sqrt{\frac{hc}{G}}$

9. For a uniform disc, moment of inertia about diameter is $\frac{MR^2}{4}$, where m is mass and R is radius of disc. Find moment of inertia about tangent parallel to diameter.

(1) $\frac{3}{4}mR^2$

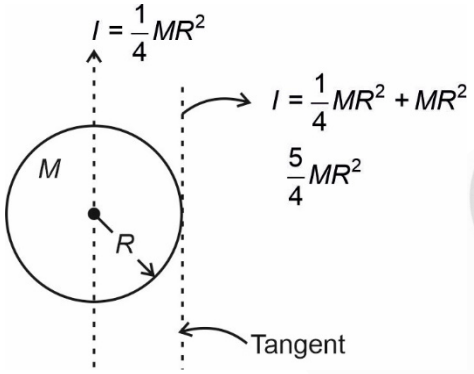
(2) $\frac{5}{4}mR^2$

(3) $\frac{3}{2}mR^2$

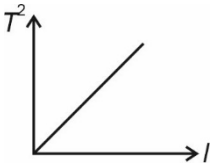
(4) $\frac{5}{2}mR^2$

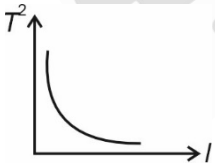
Answer (2)

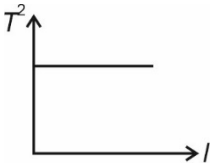
Sol.

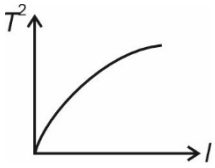


10. Which of the following graphs best represents the relation between square of time period and length of a simple pendulum?

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. $T = 2\pi\sqrt{\frac{l}{g}}$

or $T^2 = \frac{4\pi^2}{g}l$

Thus the graph between T^2 and l is a straight line passing from origin.

11. A uniform wire of resistance R is folded into a regular polygon of n sides. Find the equivalent resistance of this system between any two adjacent points.

(1) $\frac{n-1}{n}R$

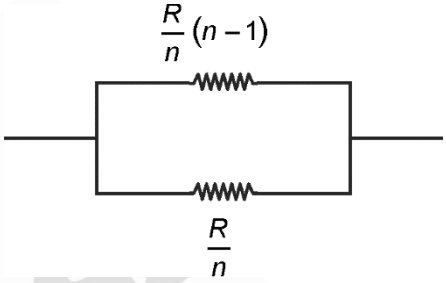
(2) $\frac{n-1}{n^2}R$

(3) $\frac{n-1}{n^3}R$

(4) $\frac{n+1}{n^2}R$

Answer (2)

Sol.



$$\Rightarrow R_{eq} = \frac{\frac{R}{n}(n-1)\times\frac{R}{n}}{\frac{R}{n}(n-1)+\frac{R}{n}}$$

$$= \frac{(n-1)\frac{R}{n}}{n}$$

$$= \frac{n-1}{n^2}R$$

12. Which of the following is correct for zener diode?

a. It acts as voltage regulator

b. It is used in forward bias

c. It is used in reverse bias

d. It is used as switch in series

(1) a and d

(2) b and c

(3) a and c

(4) b and d

Answer (3)

Sol. Zener diode acts as voltage regulator. It is used in reverse bias.

13. A train (moving with initial speed = 20 m/s) applies brakes to stop at the incoming station which is 500 m ahead.

If brakes are applied after moving 250 m, then how much beyond the station train would stop?

(1) 125 m

(2) 500 m

(3) 250 m

(4) 400 m

Answer (3)

Sol. The train needs 500 m to stop.

$\Rightarrow$ It would move beyond the station by

(500 – 250) m = 250 m.

14. For a Carnot engine working between source (at temperature T_H) and sink (at temperature T_L), efficiency is $\frac{1}{3}$. By how much amount should the sink temperature be increased so that efficiency becomes $\frac{1}{6}$?

Given $T_H = 600$ K

(1) 100 K

(2) 50 K

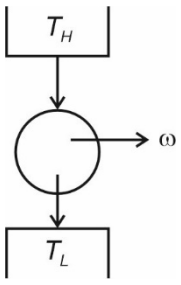
(3) 25 K

(4) 125 K

Answer (1)

Sol. $\eta = 1-\frac{T_L}{T_H} = \frac{1}{3}$

$\frac{T_L}{T_H} = \frac{2}{3}$



Now, temperature of sink is increased

$1-\frac{T_L + x}{T_H} = \frac{1}{6}$

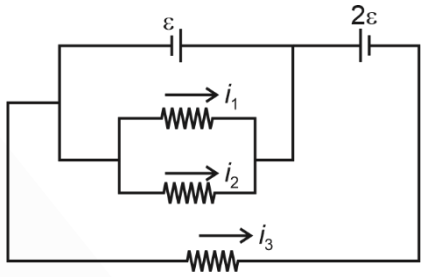
$\Rightarrow \frac{T_L + x}{T_H} = \frac{5}{6}$

$\Rightarrow \frac{x}{T_H} = \frac{5}{6} - \frac{2}{3} = \left(\frac{1}{6}\right)$

As $T_H = 600$ K

so, $x = \frac{T_H}{6} = 100$ K

15. Consider the following circuit:



All resistors have resistance 10 Ω each.

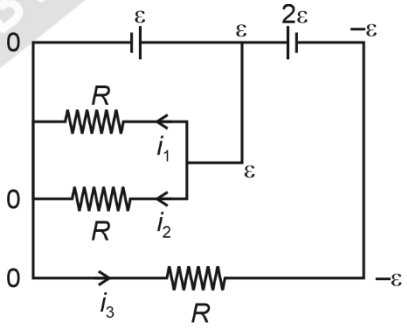
Find $\left|\frac{i_1 + i_2}{i_2}\right|$

(1) 2 (2) 1

(3) 3 (4) $\frac{1}{3}$

Answer (1)

Sol.



$i_1 = \frac{\varepsilon}{R}$

$i_2 = \frac{\varepsilon}{R}$

$i_3 = \frac{\varepsilon}{R}$

$\frac{i_1 + i_2}{i_3} = \frac{\frac{2\varepsilon}{R}}{\frac{\varepsilon}{R}} = 2$

16. **Assertion :** For making a voltmeter, we prefer a voltmeter of resistance of 400 Ω over a voltmeter of resistance of 1000 Ω.

Reason : Voltmeter should be of high resistance such that it draws less current from circuit.

(1) A and R both true R is correct explanation of A

(2) A and R both true but R is not the correct explanation of A

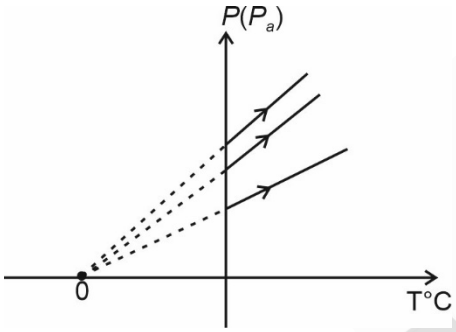
(3) A is true but R is false

(4) A is false but R is true

Answer (1)

Sol. The reason is correctly explaining the statement as, if more current is drawn the net resistance of circuit will change and we cannot get correct value of potential difference. To avoid this we choose higher resistance.

17. According to the shown *P*-*T* graph of three processes temperature at point 0 is equal to



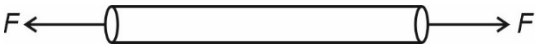
(1) –0°C (2) –373°C

(3) 100°C (4) –273°C

Answer (4)

Sol. All the gases will cease to exist at –273°C therefore the pressure will be zero so the temperature of point 0 is –273°C

18. A wire of length *l*, cross-sectional area *A* is pulled as shown:



Y is the Young's modulus of wire.

Find the elongation in wire if:

$F = 100$ N $A = 10$ cm^2

$l = 1$ m $Y = 5 \times 10^{10}$ N/m^2

(1) 10^{-6} m

(2) 10^{-5} m

(3) 2×10^{-6} m

(4) 2×10^{-5} m

Answer (3)

Sol. $\Delta l = \frac{Fl}{Ay}$

$= 2 \times 10^{-6}$ m

19. In a YDSE setup, if a mica sheet of thickness '*t*' and refractive index μ is inserted in front of one of the slits. Find the number of fringes by which the central fringe gets shifted

[Given λ, *D* and *d* are wavelength of light, distance between slits and screen and slit separation respectively]

(1) $\frac{\mu t}{\lambda}$ (2) $\frac{(\mu-1)t}{\lambda}$

(3) $\frac{(\mu+1)t}{\lambda}$ (4) $\frac{(2\mu-1)t}{\lambda}$

Answer (2)

Sol. Path difference due to mica sheet = $(\mu - 1)t$

Number of fringes shift $= \frac{\left[(\mu-1)tD\right]}{\left(\frac{\lambda D}{D}\right)}$

$= \frac{(\mu-1)t}{\lambda}$

20. Choose the correct statement regarding a ground-to-ground projectile:

(1) Kinetic energy is zero at highest point.

(2) Potential energy is highest at highest point.

(3) Horizontal component of velocity increases.

(4) Vertical component of velocity remains constant.

Answer (2)

Sol. Potential energy is highest at maximum height.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. If a force F applied on a object moving along y-axis varies with y-coordinate as

$F = 3 + 2y^2$

The work done in displacing the body from $y = 2$ m to $y = 5$ m is _____J.

Answer (87.00)

Sol. $F = 3 + 2y^2$

Work done = $\int F dy$

$$= \int_2^5 \left(3 + 2y^2\right) dy$$

$$= \left[3y + \frac{2}{3}y^3\right]_2^5$$

$$= 15 + \frac{250}{3} - 6 - \frac{16}{3}$$

$$= 9 + \frac{234}{3}$$

$$= \frac{27 + 234}{3} = \frac{261}{3} = 87 \text{ J}$$

22. In electromagnetic wave, the ratio of energy carried by electric field to that by magnetic field is

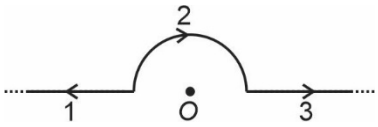
Answer (01.00)

Sol. Both carry same energy.

23. An infinite wire is bent in the shape as shown in the figure with portion AOB being semi-circular of radius R. If current I flows through the wire then magnetic field at the centre O is equal to $\frac{\mu_0 i}{kR}$. Value of k is equal to

Answer (04.00)

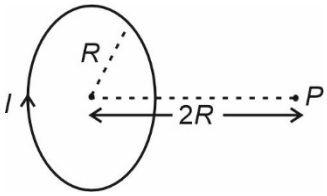
Sol.



Magnetic field due to section 1 and 3 of the wire will be zero at O is in line to the wire, therefore field will be due to section 2 only thus $B = \frac{\mu_0 i}{4\pi R} \times \pi = \frac{\mu_0 i}{4R}$

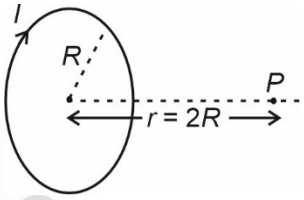
24. The magnetic field induction at point P on axis as shown in figure is $\frac{\mu_0 I}{x\sqrt{5}R}$.

Find x



Answer (10.00)

Sol.



$$B_P = \left(\frac{\mu_0}{4\pi}\right)\frac{(2\mu)}{\left(R^2 + r^2\right)^{3/2}}$$

$$= \frac{\mu_0}{2\pi}\frac{I \times \pi R^2}{\left(R^2 + r^2\right)^{3/2}}$$

$$= \frac{\mu_0 I R^2}{2\left(R^2 + r^2\right)^{3/2}}$$

as $r = 2R$

$$= \frac{\mu_0 I R^2}{2\left(R^2 + 4R^2\right)^{3/2}}$$

$$= \left(\frac{\mu_0 I}{10\sqrt{5}R}\right)$$

25. ??

26. ??

27. ??

28. ??

29. ??

30. ??

CHEMISTRY

SECTION – A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. Which of the following option contains the Nessler's reagent?
   (1) $K_2[HgI_4]$ (2) $K_2Cr_2O_7$
   (3) $K_4[Fe(CN)_6]$ (4) $K_3[Cu(CN)_4]$

Answer (1)

Sol. Nessler's reagent is $K_2[HgI_4]$

2. Find out depression in freezing point (ΔT_f) for CH_3COOH (α = 20%) dissolved in aqueous solution having 10% (w/w) CH_3COOH in solution.
   Given K_F of water = 1.86 K. kg mole^{-1}
   (1) 4.13 K (2) 2.13 K
   (3) 1.13 K (4) 0.13 K

Answer (1)

Sol. Molality = $\frac{10\times1000}{(60)(90)} = \frac{100}{54}$

$(\Delta T_F) = (i)\,(K_F)\,(m)$

$= (1.2)\times(1.86)\left(\frac{100}{54}\right)$

3. The spin only magnetic moment of Mn^{2+} in $[Mn(H_2O)_6]^{2+}$ is
   (1) 2.87 B.M.
   (2) 3.87 B.M.
   (3) 5.91 B.M.
   (4) 1.73 B.M.

Answer (3)

Sol. Mn^{2+} in $[Mn(H_2O)_6]^{2+}$ has $t_{2g}^3e_g^2$ configuration.
Thus total unpaired e^- = 5

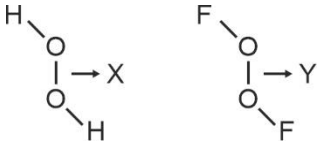
$\therefore$ Spin only magnetic moment = $\sqrt{5(5+2)}$

= 5.91 B.M.

4. Consider the H_2O_2 and O_2F_2 molecules where X and Y are O – O bond lengths in H_2O_2 and O_2F_2 respectively. Compare X and Y.
   (1) X > Y
   (2) X < Y
   (3) X = Y
   (4) X and Y cannot be compared

Answer (1)

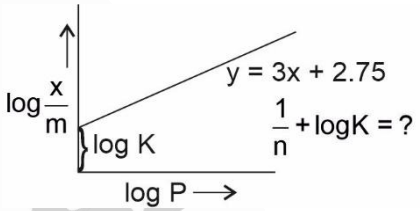
Sol.



Both H_2O_2 and O_2F_2 have open book like structure. According to Bent rule, the more electronegative atom in a molecule extracts higher p-character. In H_2O_2, O-atom is more electronegative than H-atom and hence extracts higher p-character. In O_2F_2, F-atom is more electronegative than O-atom and hence extracts higher p-character. Therefore, O-atom in O_2F_2 will have higher s-character.

Hence, O – O bond length in H_2O_2(X) will be more than O – O bond length in O_2F_2(Y).

5.



(1) 2.75 (2) 3.75
(3) 6.75 (4) 5.75

Answer (4)

Sol. $\log\frac{x}{m} = \log K + \frac{1}{n}\log P$

On comparison with y = 3X + 2.75

we have

log K = 2.75

$\frac{1}{n} = 3$

$\therefore \quad \frac{1}{n} + \log K = 3 + 2.75$

= 5.75

6. Which of the following acts as a tranquilizer?
   (1) Aminoglycoside (2) Chloramphenicol
   (3) Aspirin (4) Valium

Answer (4)

Sol. The correct answer is Valium.

7. Which of the following order is correct regarding magnitude of first electron gain enthalpy?

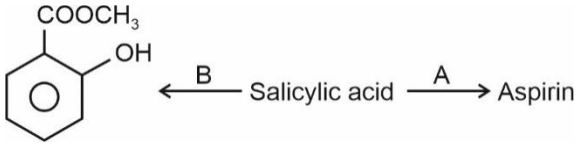
(1) Cl < F (2) O < S

(3) Te < O (4) S < Se

Answer (2)

Sol. $|\Delta H_{eg}|$ order : Cl > F > Br > I

S > Se > Te > O

8. 

Find out correct statement regarding A and B.

(1) A : Methanol/H^+

B : Ethanoic anhydride

(2) A : Ethanol/H^+

B : Ethanoic anhydride

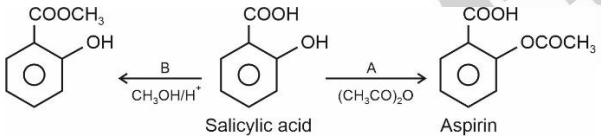
(3) A : Ethanoic anhydride

B : Methanol/H^+

(4) A : Ethanoic anhydride

B : Ethanol/H^+

Answer (3)

Sol. 

9. Which of the following given complexes has 2 isomers?

(1) $\left[Co(NH_3)_5NO_2\right]^{2+}$

(2) $\left[Co(NH_3)_5Cl\right]^{2+}$

(3) $\left[Co(NH_3)_6\right]^{3+}$

(4) $\left[Co(NH_3)_5Br\right]^{+2}$

Answer (1)

Sol. : $\left[Co(NH_3)_5NO_2\right]^{+2}$ can show linkage isomerism so, correct answer is option (1)

10. Which of the following reactions will not result in the formation of H_2O_2.

(1) $BaO_2.8H_2O(s) + H_2SO_4(aq)$

(2) 2-ethylanthraquinol $\xrightarrow{O_2}$

(3) $KO_2 + H_2O \rightarrow$

(4) $Na_2O + H_2O \rightarrow$

Answer (4)

Sol. $BaO_2.8H_2O(s) + H_2SO_4(aq) \rightarrow BaSO_4(s) + H_2O_2(aq) + 8H_2O$

2-ethylanthraquinol $\underset{H_2/Pd}{\overset{O_2}{\rightleftharpoons}} H_2O_2$ + oxidised product

$2KO_2 + 2H_2O \rightarrow 2KOH + O_2 + H_2O_2$

$Na_2O + H_2O \rightarrow 2NaOH$

Hence correct answer in option (4)

11. Which of the following industry contributes maximum to global warming?

(1) Oil industry (2) Fertilizer industry

(3) Paper industry (4) Ice factory

Answer (1)

Sol. Oil industry contributes maximum to the global warming.

12. An electron in Be^{3+} goes from n = 4 to n = 2. Find out energy released in eV.

(Ground state energy of H-atom = 13.6 eV)

(1) 40.8 eV (2) 122.4 eV

(3) 217.6 eV (4) 21.17 eV

Answer (1)

Sol. Energy released

$$= 13.6 \times (Z)^2 \left(\frac{1}{(2)^2} - \frac{1}{(4)^2}\right)$$

$$= 13.6 \times 16 \times \left(\frac{1}{4} - \frac{1}{16}\right)$$

$$= 13.6 \times 16 \left(\frac{3}{16}\right)$$

= 40.8 eV

13. **Assertion :** Gypsum is used to slow down the setting of cement.

Reason : Gypsum is unstable at high temperature.

(1) Both Assertion and Reason are correct

(2) Assertion is correct, Reason is incorrect

(3) Assertion is incorrect, Reason is correct

(4) Both Assertion and Reason are incorrect

Answer (1)

Sol. Gypsum is added in small amount to slow down the setting of cement. So, assertion is correct.

Gypsum is thermally instable at high temperature as it undergoes dehydration up to 300°C and dissociates at high temperature to CaO and SO_3. So, reason is also correct.

14. Compare enthalpy of vaporisation (ΔH_{vap}) for H_2O, D_2O & T_2O

(1) $H_2O > D_2O > T_2O$

(2) $H_2O > T_2O > D_2O$

(3) $T_2O > D_2O > H_2O$

(4) $T_2O > H_2O > D_2O$

Answer (3)

Sol. : ΔH_{vap} $H_2O = 40.66 \ \frac{kJ}{mole}$

$D_2O = 41.61 \ \frac{kJ}{mole}$

15. The correct order of bond strength of C–C, Si–Si, Ge–Ge, Sn–Sn is____?

(1) C–C > Si–Si > Ge–Ge > Sn–Sn

(2) C–C > Si–Si > Ge–Ge ≃ Sn–Sn

(3) C–C < Si–Si < Ge–Ge < Sn–Sn

(4) C–C > Si–Si > Sn–Sn > Ge–Ge

Answer (1)

Sol. Bond strength decreases on moving down. For carbon family

16. Consider the following reaction

$$\underset{(g)}{PCl_5} \rightleftharpoons \underset{(g)}{PCl_3} + \underset{(g)}{Cl_2}$$

Select the correct statement about the above equilibrium.

(1) On adding He gas at constant volume equilibrium shift in forward direction

(2) On adding He gas at constant pressure equilibrium shift in forward direction

(3) On adding He gas at constant pressure equilibrium shift in backward direction

(4) On adding He gas at constant volume, equilibrium shift in backward direction

Answer (2)

Sol. On adding He gas at constant volume equilibrium remains unaffected.

On adding He gas at constant pressure equilibrium shift in that direction in which number of gaseous molecule are greater.

Hence the correct answer is 2.

17. Which of the following option contains all the isoelectronic species?

(1) N^{3-}, O^{2-}, F, Na

(2) S^{-2}, $Cl^{\ominus}$, $K^{\oplus}$, Ca^{+2}

(3) NH_3, CH_4, PF_5, $Na^{\oplus}$

(4) Ne, $Na^{\oplus}$, F, N^{-3}

Answer (2)

Sol. S^{2-}, $Cl^{\ominus}$, $K^{\oplus}$ and Ca^{2+} all the species contain 18 electrons.

18. Identify the correct bond dissociation energy of halogens.

(1) $F_2 > Cl_2$

(2) $Br_2 > F_2$

(3) $I_2 > F_2$

(4) $Br_2 > Cl_2$

Answer (2)

Sol. The correct bond dissociation energy of halogens is

$Cl_2 > Br_2 > F_2 > I_2$

19. Given : $\lambda^{o}_{M NO_3^-} = 71.5 \ S \ cm^2 \ mol^{-1}$

$\lambda^{o}_{M Br^-} = 78.1 \ S \ cm^2 \ mol^{-1}$

$\lambda^{o}_{M Ag^+} = 61.9 \ S \ cm^2 \ mol^{-1}$

Find out conductivity of solution when 1 mole of $AgNO_3$ is dissolved in 1 L of AgBr saturated solution. (K_{sp} of AgBr = 10^{-13})

(1) 133.4×10^{-3} S cm^{-1} (2) 62.4×10^{-3} S cm^{-1}

(3) 78.1×10^{-3} S cm^{-1} (4) 96.5×10^{-3} S cm^{-1}

Answer (1)

Sol. AgBr conductivity is negative.

For Ag^+,

$$61.9 = \frac{K \times 1000}{1}$$

$$K_{Ag^+} = 61.9 \times 10^{-3}$$

For NO_3^-,

$$71.5 = \frac{K \times 1000}{1}$$

$$K_{NO_3} = 71.5 \times 10^{-3}$$

K_{total} = (61.9 + 71.5) × 10^{-3}

= 133.4 × 10^{-3} S cm^{-1}

20.

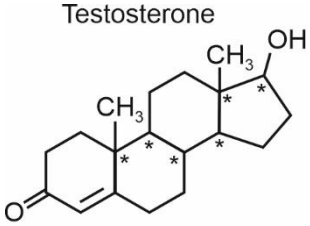
SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. Number of Chiral carbons in 1 molecule of testosterone

Answer (06.00)

Sol. Testosterone



6 Chiral Carbons

22. An atom forms two lattice FCC and BCC. The edge length of FCC lattice is 2.5 Å and edge length of BCC lattice is 2 Å. Then find the ratio of density of FCC to density of BCC. (Round off to nearest integer)

Answer (1)

Sol. For FCC

$$\sqrt{2} \times 2.5 = 4r$$

$$\therefore \quad r = \frac{2.5 \times \sqrt{2}}{4}$$

$$\therefore \quad d_{FCC} = \frac{4 \times M}{a^3}$$

For BCC

$$\sqrt{3} \times 2 = 4r$$

$$r = \frac{\sqrt{3} \times 2}{4}$$

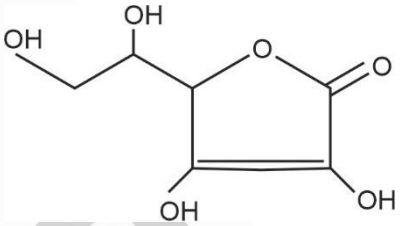
$$d_{BCC} = \frac{2 \times M}{a^3}$$

$$\therefore \quad \frac{d_{FCC}}{d_{BCC}} = \frac{4 \times M}{(2.5)^3} \times \frac{(2)^3}{2 \times M}$$

$$= 1.024$$

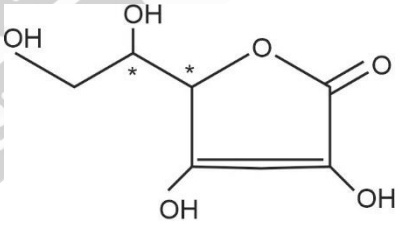
$$\approx 1$$

23. Find number of asymmetrical carbon in structure of vitamin C (Given in question).



Answer (2)

Sol.



2 Chiral Carbons

24. For a first order reaction half-life ($t_{1/2}$) is 50 minutes. Then find the $t_{3/4}$ (in minutes) of the reaction?

Answer (100)

Sol. $1 \xrightarrow{t_{1/2}} \frac{1}{2} \xrightarrow{t_{1/2}} \frac{1}{4}$

$\therefore$ $t_{3/4}$ will be 100 minutes.

25.

26.

27.

28.

29.

30.

MATHEMATICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer :

1. If the term independent of x in the expansion of $\left(x^{\frac{2}{3}}+\frac{\alpha}{x^3}\right)^{22}$ is 7315, then $|\alpha|$ is

(1) 1

(2) 2

(3) 0

(4) 3

Answer (1)

Sol. $T_{r+1}={}^{22}C_r\left(x^{\frac{2}{3}}\right)^{22-r}\left(\frac{\alpha}{x^3}\right)^r$

$\Rightarrow \frac{2(22-r)}{3}-3r=0$

$\Rightarrow 44-2r-9r=0 \Rightarrow r=4$

$\therefore T_5={}^{22}C_4\alpha^4=7315$

$\alpha^4=\frac{7315}{7315}$

$\Rightarrow |\alpha|=1$

2. The value of $\int\limits_{-\frac{\pi}{4}}^{\frac{\pi}{4}}\frac{x+\frac{\pi}{4}}{2-\cos 2x}dx$ equals

(1) $\frac{3\pi^2}{\sqrt{6}}$

(2) $\sqrt{3}\pi^2$

(3) $\frac{\pi^2}{6\sqrt{3}}$

(4) $\frac{6\pi^2}{\sqrt{3}}$

Answer (3)

Sol. $I=\int\limits_{-\frac{\pi}{4}}^{\frac{\pi}{4}}\frac{x\,dx}{2-\cos 2x}+\frac{\pi}{4}\int\limits_{-\frac{\pi}{4}}^{\frac{\pi}{4}}\frac{dx}{2-\cos 2x}$

$=0+\frac{\pi}{4}\cdot 2\int\limits_0^{\frac{\pi}{4}}\frac{dx}{2-\cos 2x}$

$=\frac{\pi}{2}\int\limits_0^{\frac{\pi}{4}}\frac{\sec^2 x\,dx}{1+3\tan^2 x}$

Now, $\tan x = t$

$=\frac{\pi}{2}\int\limits_0^1\frac{dt}{1+3t^2}$

$=\frac{\pi}{2\sqrt{3}}\tan^{-1}\left(\sqrt{3}t\right)\Big|_0^1$

$=\frac{\pi}{2\sqrt{3}}\left(\frac{\pi}{3}\right)=\frac{\pi^2}{6\sqrt{3}}$

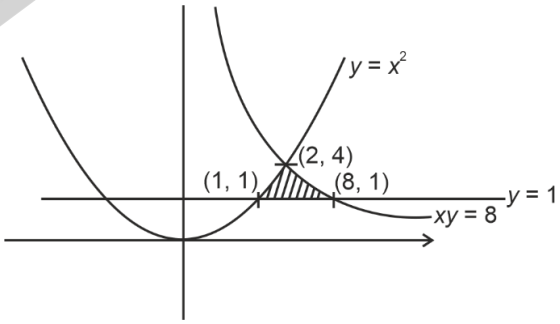
3. The area determined by $xy < 8$, $y < x^2$ and $y > 1$ is

(1) $4\ln 2-\frac{14}{3}$ (2) $4\ln 2+\frac{20}{3}$

(3) $8\ln 4-\frac{14}{3}$ (4) $8\ln 4-\frac{20}{3}$

Answer (3)

Sol.



$\therefore$ Area $=\int\limits_1^2\left(x^2-1\right)dx+\int\limits_2^8\left(\frac{8}{x}-1\right)dx$

$=\frac{x^3}{3}-x\Big|_1^2+\left(8\ln x-x\right)\Big|_2^8$

$=\left(\frac{8}{3}-2\right)-\left(\frac{1}{3}-1\right)+\left(8\ln 8-8\right)-\left(8\ln 2-2\right)$

$=\frac{4}{3}+8\ln 4-6=8\ln 4-\frac{14}{3}$

4. If $f(x)+f\left(\frac{1}{1-x}\right)=1-x$, then $f(2)$ equals

(1) $\frac{1}{4}$ (2) $\frac{-5}{4}$

(3) $\frac{3}{4}$ (4) $-\frac{3}{4}$

Answer (2)

Sol. $f(x)+f\left(\frac{1}{1-x}\right)=1-x$ …(i)

Put $x = 2$ in (i)

$f(2) + f(-1) = -1$ …(ii)

Put $x = -1$ in (i)

$f(-1)+f\left(\frac{1}{2}\right)=2$ …(iii)

Put $x=\frac{1}{2}$ in (i)

$f\left(\frac{1}{2}\right)+f(2)=\frac{1}{2}$ …(iv)

From (iii) and (iv)

$2-f(-1)=\frac{1}{2}-f(2)$

$f(-1)=\frac{3}{2}+f(2)$ …(v)

From (ii) and (v)

$-1-f(2)=\frac{3}{2}+f(2)$

$2f(2)=-1-\frac{3}{2}=\frac{-5}{2}$

$\boxed{f(2)=\frac{-5}{4}}$

5. If $f(x) = x^x$, $x > 0$ then $f''(2) + f'(2)$ is

(1) $10 + 12 \ln 2 + 4 (\ln 2)^2$

(2) $10 + 4 (\ln 2)^2$

(3) $10 + 12 \ln 2$

(4) $2^{\ln 2} + (\ln 2)^2$

Answer (1)

Sol. $y = x^x$

$\therefore \quad f'(2) = 4(1 + \ln 2)$

$y' = x^x (1 + \ln x)$

$y''=\frac{x^x}{x}+x^x(1+\ln x)^2$

$\Rightarrow \quad f''(2) = 2 + 4 (1 + \ln 2)^2$

$f''(2) + f'(2) = 4 + 4\ln 2 + 6 + 8 \ln 2 + 4(\ln 2)^2$

$= 10 + 12 \ln 2 + 4 (\ln 2)^2$

6. Which of the following is a tautology?

(1) $p \to (\sim p \wedge q)$ (2) $p \to (p \vee q)$

(3) $p \to (\sim p \vee q)$ (4) $p \to (\sim p \wedge \sim q)$

Answer (2)

Sol. For tautology of $p \to q$

(i) $p \to$ T and $q \to$ T OR

(ii) $p \to$ F and $q \to$ T or F

So, option (2) is true.

7. If the system of equations

$\alpha x + y + z = 1$

$x + \alpha y + z = 1$

$x + y + \alpha z = \beta$ has infinitely many solutions, then

(1) $\alpha = 1, \beta = 1$ (2) $\alpha = 1, \beta = -1$

(3) $\alpha = -1, \beta = -1$ (4) $\alpha = -1, \beta = 1$

Answer (1)

Sol. For infinite solutions

$\Delta = \Delta_x = \Delta_y = \Delta_z = 0$

$\Rightarrow \begin{vmatrix}\alpha & 1 & 1\\ 1 & \alpha & 1\\ 1 & 1 & \alpha\end{vmatrix}=\begin{vmatrix}1 & 1 & 1\\ 1 & \alpha & 1\\ \beta & 1 & \alpha\end{vmatrix}=\begin{vmatrix}\alpha & 1 & 1\\ 1 & 1 & 1\\ 1 & \beta & \alpha\end{vmatrix}=\begin{vmatrix}\alpha & 1 & 1\\ 1 & \alpha & 1\\ 1 & 1 & \beta\end{vmatrix}=0$

$\therefore \quad \alpha = 1 = \beta$

Clearly $\alpha = \beta = 1$ makes all the above equations identical i.e., three co-incidence planes.

8. If $A=\frac{1}{2}\begin{bmatrix}1 & \sqrt{3}\\ -\sqrt{3} & 1\end{bmatrix}$, then which of the following is true?

(1) $A^{30} = A^{25}$ (2) $A^{30} + A^{25} + A = I$

(3) $A^{30} - A^{25} + A = I$ (4) $A^{30} = A^{25} + A$

Answer (3)

Sol. $\begin{bmatrix}\frac{1}{2} & \frac{\sqrt{3}}{2}\\ -\frac{\sqrt{3}}{2} & \frac{1}{2}\end{bmatrix}$

$|A - \lambda I| = 0$

$\begin{vmatrix}\frac{1}{2}-\lambda & \frac{\sqrt{3}}{2}\\ -\frac{\sqrt{3}}{2} & \frac{1}{2}-\lambda\end{vmatrix}=0$

$\lambda^2+\frac{1}{4}-\lambda+\frac{3}{4}=0$

$A^2 - A + I = 0 \Rightarrow A^3 - A^2 + A = 0$

$A^4 = (A - I)^2 = A^2 + I - 2A = A - I + I - 2A = -A$

$\boxed{A^4 = -A}$

$A^{30} - A^{25} + A = A^2(A^4)^7 - (A^4)^6 \cdot A + A$

$= -A^2A^7 - A^6 \cdot A + A$

$= -A^9 - A^7 + A$

$= -A^8 \cdot A - A^4 \cdot A^3 + A$

$= -A^3 - A + A$

$= -A^3$

$= A - A^2$

$= I$

9. 2 unbiased die are thrown independently. A is the event such that the number on the first die is greater than second die. B is the event such that number on the first die is even and number on the second die is odd. C is the event such that first die shows odd number & second die shows even number. Then,

(1) $n\left((A \cup B) \cap C\right) = 6$

(2) A and B are mutually exclusive events

(3) A and B are independent events

(4) $n(A) = 18,\ n(B) = 6,\ n(C) = 6$

Answer (1)

Sol. $n(S) = 36$

$$A = \begin{Bmatrix} (1,2), (1,3), (1,4), (1,5), (1,6) \\ (2,3), (2,4), (2,5), (2,6) \\ (3,4), (3,5), (3,6) \\ (4,5), (4,6) \\ (5,6) \end{Bmatrix}$$

$n(A) = 15$

$$B = \begin{Bmatrix} (2,1), (2,3), (2,5) \\ (4,1), (4,3), (4,5) \\ (6,1), (6,3), (6,5) \end{Bmatrix}$$

$n(B) = 9$

$$C = \begin{Bmatrix} (1,2), (1,4), (1,6) \\ (3,2), (3,4), (3,6) \\ (5,2), (5,4), (5,6) \end{Bmatrix}$$

$n(C) = 9$

$P(A) = \frac{15}{36},\ P(B) = \frac{9}{36},\ P(C) = \frac{9}{36}$

$n(B \cap C) = 0$

$A \cap B = \{(2,3), (2,5), (4,5)\}$

$P(A \cap B) = \frac{3}{36} = \frac{1}{12}$

$P(A) \cdot P(B) = \frac{15}{36} \cdot \frac{6}{36}$

$= \frac{5}{72}$

$$\left((A \cup B) \cap C\right) = \begin{Bmatrix} (1,2), (1,4), (1,6) \\ (3,4), (3,6) \\ (5,6) \end{Bmatrix}$$

$n\left((A \cup B) \cap C\right) = 6$

10. If $\frac{dy}{dx} = \frac{x^2 + 3y^2}{3x^2 + y^2}$, $y(1) = 0$ Then

(1) $\frac{2x^2}{(x^2 - y^2)^2} = \ln|x - y| + \frac{2x}{x - y}$

(2) $\frac{2x}{(x^2 - y^2)^2} = \ln|x - y| + 1$

(3) $\frac{2x^2}{(x^2 - y^2)^2} = \ln|x - y| + \frac{y}{x - y}$

(4) $\frac{2x}{(x^2 - y^2)^2} = \ln|x - y| + \frac{y}{x - y}$

Answer (1)

Sol. $\frac{dy}{dx} = \frac{x^2 + 3y^2}{3x^2 + y^2}$

Let $y = vx$

$\frac{dy}{dx} = v + x\frac{dv}{dx}$

So, $v + x\frac{dv}{dx} = \frac{1 + 3v^2}{3 + v^2}$

$x\frac{dv}{dx} = \frac{1 + 3v^2}{3 + v^2} - v = \frac{-v^3 + 3v^2 - 3v + 1}{v^2 + 3}$

$\frac{v^2 + 3}{-v^3 + 3v^2 - 3v + 1}dv = \frac{1}{x}dx$

$\Rightarrow \int \frac{v^2 + 3}{(1 - v)^3}dv = \frac{1}{x}dx$

$\Rightarrow \int \frac{1}{1 - v}dv - \int \frac{2dv}{(1 - v)^2} + \int \frac{4}{(1 - v)^3}dv = \int \frac{1}{x}dx$

$\Rightarrow \quad -\ln|-v| - \frac{2}{1-v} + \frac{2}{(1-v)^2} = \ln|x| + C$

$\because \quad y(1) = 0, \Rightarrow v(1) = 0$

$\Rightarrow \quad \boxed{C = 0}$

$\therefore \quad \frac{2}{\left(1-\frac{y}{x}\right)^2} = \ln\left|1-\frac{y}{x}\right| + \frac{2}{1-\frac{y}{x}} + \ln(x)$

$\Rightarrow \quad \frac{2x^2}{(x^2-y^2)^2} = \ln|x-y| + \frac{2x}{x-y}$

11. $\vec{a} = \hat{i} - \hat{j} + \hat{k}$, $\vec{b} = 2\hat{i} - 3\hat{j} + \hat{k}$, $\vec{c} = 4\hat{i} + 5\hat{j} - \hat{k}$. If $\vec{r} \cdot \vec{b} = 0$ and $\vec{r} \times \vec{a} = \vec{b} \times \vec{c}$ then $\vec{r}$ is equal to

(1) $-12\hat{i} - 8\hat{j} + \hat{k}$ (2) $-12\hat{i} - \frac{23}{3}\hat{j} + \hat{k}$ (3) $12\hat{i} + \frac{23}{3}\hat{j} + \hat{k}$ (4) $12\hat{i} + 8\hat{j} + \hat{k}$

Answer (2)

Sol. $\vec{r}\ \vec{a} = \vec{b} \times \vec{c}$

$\vec{b} \times (\vec{r} \times \vec{a}) = \vec{b} \times (\vec{b} \times \vec{c})$

$\vec{b} \cdot \vec{a}\ \vec{r} - \vec{b} \cdot \vec{r}\ \vec{a} = \vec{b} \cdot \vec{c}\ \vec{b} - \vec{b} \cdot \vec{b}\ \vec{c}$

$6\vec{r} = -8(2\hat{i} - 3\hat{j} + \hat{k}) - 14(4\hat{i} + 5\hat{j} - \hat{k})$

$6\vec{r} = -72\hat{i} - 46\hat{j} + 6\hat{k}$

$\vec{r} = -12\hat{i} - \frac{23}{3}\hat{j} + \hat{k}$

12. If $2\tan^{-1}\left(\frac{1-x}{1+x}\right) = \cos^{-1}\left(\frac{1-x^2}{1+x^2}\right)$, $x \in (0, 1)$ has

(1) 2 solutions for $x < \frac{1}{2}$

(2) 2 solutions for $x > \frac{1}{2}$

(3) One solution for $x < \frac{1}{2}$

(4) One solution for $x > \frac{1}{2}$

Answer (3)

Sol. Put $x = \tan\theta$ we get

$2\tan^{-1}\left(\tan\left(\frac{\pi}{4} - \theta\right)\right) = \cos^{-1}\cos 2\theta$

$2\left(\frac{\pi}{4} - \theta\right) = 2\theta$

$\Rightarrow \quad \theta = \frac{\pi}{8}$

$\therefore \quad x = \sqrt{2} - 1$ only one value $< \frac{1}{2}$

13.

14.

15.

16.

17.

18.

19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. Number of non-negative integral solutions of $x + y + z = 21$ if $x \geq 1$, $y \geq 3$, $z \geq 6$

Answer (78)

Sol. $\because \quad x + y + z = 21 \qquad [\because x \geq 1, y \geq 3, z \geq 6]$

then $x_1 + y_1 + z_1 = 11$

Now $x_1 \geq 0$, $y_1 \geq 0$, $z_1 \geq 0$

Total ${}^{11+3-1}C_{3-1}$ solution

${}^{13}C_2 = \frac{13!}{2!11!} = 6 \times 13 = 78$

22. Total 6 digit numbers using the digits 4, 5, 9 which are divisible by 6 are

Answer (81.00)

Sol. For this, 4 will be fixed on unit place digit

		Total number
Case-I	4's $\rightarrow$ 6 time	1
Case-II	4's $\rightarrow$ 4 time	$\frac{5!}{3!}=20$
	5's $\rightarrow$ 1 time	
	9's $\rightarrow$ 1 time	
Case-III	4's $\rightarrow$ 3 time	$\frac{5!}{2!3!}=10$
	5's $\rightarrow$ 3 time	
Case-IV	4's $\rightarrow$ 3 time	$\frac{5!}{2!3!}=10$
	9's $\rightarrow$ 3 time	
Case-V	4's $\rightarrow$ 2 time	$\frac{5!}{2!2!}=30$
	5's $\rightarrow$ 2 time	
	9's $\rightarrow$ 2 time	
Case-VI	4's $\rightarrow$ 1 time	$\frac{5!}{4!}=5$
	5's $\rightarrow$ 1 time	
	9's $\rightarrow$ 4 time	
Case-VII	4's $\rightarrow$ 1 time	$\frac{5!}{4!}=5$
	5's $\rightarrow$ 4 time	
	9's $\rightarrow$ 1 time	

Total numbers = 81

23. Let 3 A.P's be

S_1 = 2, 5, 8, 11, ……..394

S_2 = 1, 3, 5, 7, ……397

and S_3 = 2, 7, 12, ……..397

then sum of common terms of these three A.P's is

Answer (2364)

Sol. S_2 has all odd numbers upto 397

$\therefore$ Common terms in S_1 and S_2 gives 5, 11, 17, 23, …….391 = S_4

Common terms S_3 and S_2 … 7, 17, 27, ……..397 = S_5

$\therefore$ Required terms will be common terms of S_4 and S_5

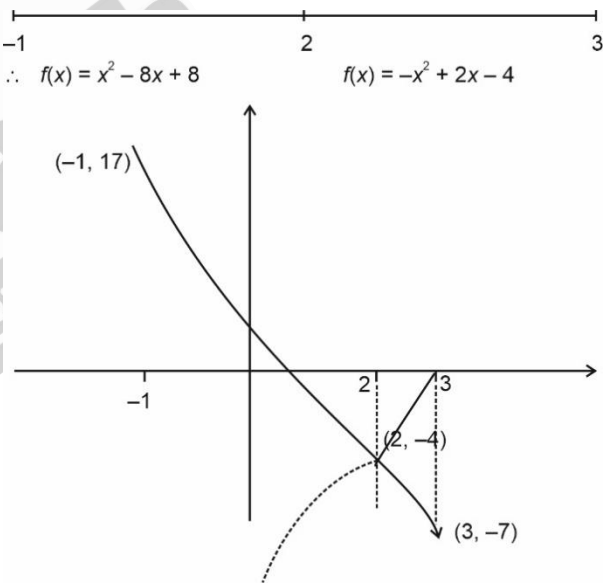
i.e., 17, 47, 77, 107, ……..377

$$\text{Sum}=\frac{12}{2}(17+377)=2364$$

24. Let $f(x) = |(x-3)(x-2)| - 3x + 2$ for $x \in [1, 3]$. If m and M are absolute maximum and absolute minimum value of $f(x)$ then $|m| + |M|$ equals

Answer (24)

Sol.



$\therefore$ $m = -7$ and $M = 17$

$\therefore$ $|m| + |M| = 7 + 17 = 24$

25. Let $X_1, X_2, X_3 \ldots X_7$ is an A.P. such that $X_1 < X_2 < X_3 \ldots < X_7$, $X_1 = 9$, $\sigma = 4$. The value of $\overline{X} + X_6$ is equal to _____.

Answer (34)

Sol. Let the series be $a - 3d$, $a - 2d$, $a - d$, a, $a + d$, $a + 2d$, $a + 3d$, $a - 3d = 9$

Now, if we shift the origin, the variance remains same and $\bar{x}$ became $\bar{x}-a$

$\therefore$ For $-3d, -2d, -d, 0, d, 2d, 3d$

$$16=\frac{2}{7}\left(9d^2+4d^2+d^2\right)-\left(\bar{x}-a\right)^2$$

$$\Rightarrow \quad 16=\frac{2}{7}d^2(14)-(0)^2$$

$\Rightarrow \quad d = 2$

$a - 3d = 9$

$\Rightarrow \quad a = 15$

$\bar{x}=15$

$x_6 = a + 2d$

$=15 + 2(2) = 19$

$\bar{x}+x_6=15+19=34$

26.

27.

28.

29.

30.

❑ ❑ ❑