

27/07/2022

Morning



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## Memory Based Answers & Solutions

Time : 3 hrs.

*for*

M.M. : 300

## JEE (Main)-2022 (Online) Phase-2

(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. A DC current of 4 A and AC current of peak value 4 A passes through 3 Ω and 2 Ω resistors respectively. Find the ratio of heat generated

- (1) 3 : 1
- (2) 3 : 2
- (3) 3 : 4
- (4) 1 : 1

**Answer (1)**

**Sol.**  $H_1 = 4^2 \times 3$

$$H_2 = \left(\frac{4}{\sqrt{2}}\right)^2 \times 2$$

$$\Rightarrow \frac{H_1}{H_2} = \frac{4^2 \times 3}{\frac{4^2}{2} \times 2}$$

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

2. In a station, the TV transmission tower is of height 100 m. In order to triple the coverage range, the height should be increased to

- (1) 200 m
- (2) 300 m
- (3) 600 m
- (4) 900 m

**Answer (4)**

**Sol.** Initial range  $x = \sqrt{2hR}$

for range = 3x

$$3x = \sqrt{2h'R}$$

$$\Rightarrow h' = 9h$$

$$= 900 \text{ m}$$

3. Two bar magnets oscillate in Earth's magnetic field and with the time period of 3 s and 4 s. If ratio of moment of inertia is 3 : 2, then the ratio of the magnetic moment is

- (1) 4 : 1
- (2) 8 : 3
- (3) 27 : 16
- (4) 2 : 1

**Answer (2)**

**Sol.**  $T = 2\pi\sqrt{\frac{I}{MB}}$

$$\Rightarrow T \propto \sqrt{I}; T \propto \frac{1}{\sqrt{M}}$$

$$\Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{M_2 I_1}{M_1 I_2}}$$

$$\frac{3}{4} = \sqrt{\frac{M_2 \cdot 3}{M_1 \cdot 2}}$$

$$\frac{M_1}{M_2} = \frac{8}{3}$$

4. Maximum error in the measurement of force is 5% and that in measurement of length is 4.5%. Maximum possible error in measurement of torque is (angle between force and position vector is known to be accurate)

- (1) 9.5%
- (2) 20%
- (3) 15%
- (4) 5%

**Answer (1)**

**Sol.**  $|\tau| = Fl \sin\theta$

$$\Rightarrow \frac{d\tau}{\tau} = \frac{dF}{F} + \frac{dl}{l} = \frac{(5 + 4.5)}{100}$$

$$\Rightarrow \% \frac{\Delta\tau}{\tau} = 9.5\%$$

5. A bag is dropped on a conveyor belt with coefficient of friction μ. The belt keeps on moving with constant speed v, The time it takes for relative motion between bag and belt to stop is

- (1)  $\frac{v}{g}$
- (2)  $\frac{v}{2\mu g}$
- (3)  $\frac{v}{\mu g}$
- (4)  $\frac{g}{v}$

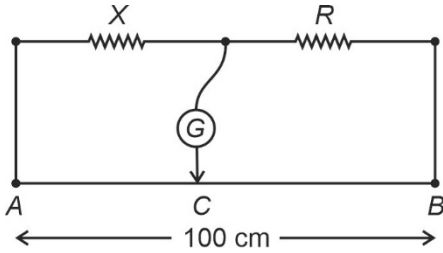
**Answer (3)**

Sol.  $a = \mu g$

$$\therefore v = \mu g t$$

$$\Rightarrow t = \frac{v}{\mu g}$$

6. In the shown meter bridge, the null point C is obtained 30 cm away from point A. If  $R = 5.6 \text{ k}\Omega$  then value of resistance of resistor X is



- (1)  $1.6 \text{ k}\Omega$                       (2)  $2.4 \text{ k}\Omega$   
 (3)  $4.8 \text{ k}\Omega$                       (4)  $5.8 \text{ k}\Omega$

**Answer (2)**

Sol.  $\frac{X}{R} = \frac{30}{70}$

$$\Rightarrow X = \frac{3}{7} \times 5.6 \text{ k}\Omega$$

$$= 2.4 \text{ k}\Omega$$

7. Waves of intensity  $I$  and  $4I$  with same frequency interfere at two points A & B such that at A phase difference between two is  $\frac{\pi}{2}$  while at B the same is

$\frac{\pi}{3}$ . The difference of net intensities at two points is equal to

- (1)  $I$                                       (2)  $7I$   
 (3)  $3I$                                       (4)  $2I$

**Answer (4)**

Sol.  $\therefore I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos \theta$

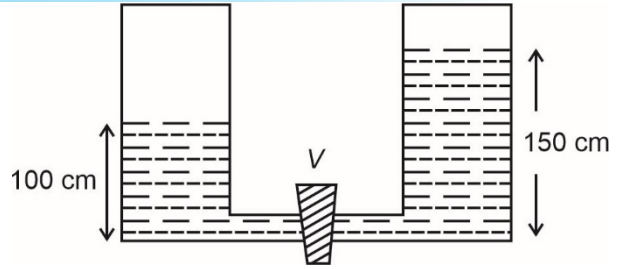
$$\therefore I_A = 5I$$

$$\text{and, } I_B = I + 4I + 4I \times \frac{1}{2}$$

$$= 7I$$

$$\Rightarrow \Delta I = 2I$$

8.



The cylinders shown have area of cross section of  $16 \text{ cm}^2$ . In one cylinder the water is raised upto 100 cm while in other the water is raised upto 150 cm. After opening of the valve V the work done by gravity when levels settle is equal to

- (1) 5 J                                      (2) 1 J  
 (3) 17.25 J                                (4) 25 J

**Answer (2)**

Sol. Initial G.P.E. =  $A\rho \left( 100 \times \frac{100}{2} + \frac{150 \times 150}{2} \right) g$

$$\text{Final G.P.E.} = 2A\rho \left( \frac{125 \times 125}{2} \right) g$$

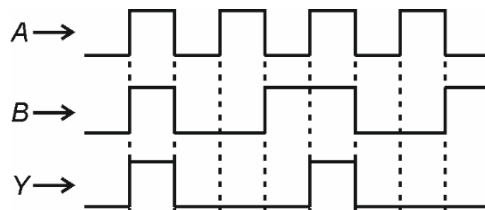
$$\Rightarrow \text{W.D. by gravity} = \frac{A\rho g}{2} (32500 - 31250)$$

$$= \frac{16 \times 10^{-4} \times 10^3 \times 10 \times 1250 \times 10^{-4}}{2}$$

$$= 10000 \times 10^{-4}$$

$$= 1 \text{ J}$$

9. The shown signals A and B are used as input to a logic gate with Y as its output

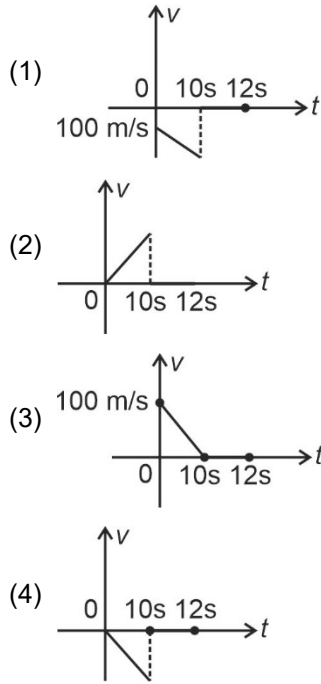


- (1) AND  
 (2) OR  
 (3) NOR  
 (4) NAND

**Answer (1)**

Sol. From the shown signal diagram at input and output, the output signal resembles with that of an AND gate.

10. A bullet is shot vertically downwards at 100 m/s and strikes ground below after 10s then it stays at rest there for further 2s. The appropriate  $v-t$  graph will be



**Answer (1)**

**Sol.** As the bullet moves downwards it moves with constant acceleration increasing its speed further from 100 m/s onwards. The graph given in option (1) matches most appropriately with the given condition.

11. Two satellites  $a$  and  $b$  of mass ratio 1:3 and its radii are  $3r$  and  $4r$ . Their ratio of total energy is

- (1)  $\frac{4}{9}$                       (2)  $\frac{16}{9}$   
(3)  $\frac{9}{4}$                       (4)  $\frac{9}{16}$

**Answer (1)**

**Sol.**  $E = -\frac{GMm_s}{2r}$

$$\Rightarrow \frac{E_1}{E_2} = \frac{m_{s1}}{m_{s2}} \times \frac{r_2}{r_1}$$

$$= \frac{1}{3} \times \frac{4}{3}$$

$$\Rightarrow \frac{E_1}{E_2} = \frac{4}{9}$$

12. A square lead slab of side 60 cm and thickness 15 cm is subjected to a shearing force (on its narrow face) of  $9 \times 10^4$  N. The lower edge is reverted to the floor. How much will be the upper edge be displaced?

Shear modulus of lead =  $6.0 \times 10^9$  Nm<sup>-2</sup>

- (1) 0.045 mm              (2) 0.025 mm  
(3) 0.06 mm              (4) 0.03 mm

**Answer (2)**

**Sol.**  $\eta = 6 \times 10^9$  N/m<sup>2</sup>

$$F = 9 \times 10^4$$

$$l = 60 \text{ cm}$$

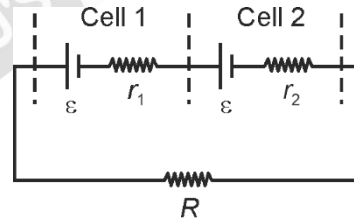
$$\frac{x}{l} = \frac{F/A}{\eta}$$

$$x = \frac{9 \times 10^4 \times 60 \times 10^{-2}}{6 \times 10^9 \times 60 \times 60 \times 10^{-4}}$$

$$= 0.025 \times 10^{-3} \text{ m}$$

$$= 0.025 \text{ mm}$$

13. Two cells, cell (1) and cell (2) are in series across the resistance  $R$ . Find the value of  $R$  such that potential difference across cell (1) is zero.



- (1)  $r_1 - r_2$               (2)  $r_1 + r_2$   
(3)  $\frac{r_1 r_2}{r_1 + r_2}$               (4)  $\frac{r_1 + r_2}{2}$

**Answer (1)**

**Sol.**  $I = \frac{2\varepsilon}{R + r_1 + r_2}$

$$V_1 = \varepsilon - Ir_1 = 0$$

$$\Rightarrow \varepsilon = Ir_1$$

$$\text{or } \varepsilon = \frac{2\varepsilon r_1}{R + r_1 + r_2}$$

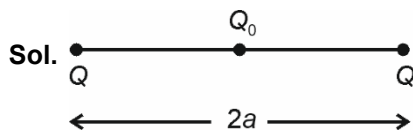
$$\Rightarrow R + r_1 + r_2 = 2r_1$$

$$R = r_1 - r_2$$

14. Two point charges each of magnitude  $Q$  are kept fixed at a distance  $2a$  from each other. A third charge  $Q_0$  is kept at middle of the two charges and is displaced a little along the line joining the two charges. The period of oscillation is (mass of charge  $Q_0$  is equal to  $m$ )

(1)  $\frac{\pi a}{2} \sqrt{\frac{ma}{KQQ_0}}$       (2)  $\pi a \sqrt{\frac{ma}{KQQ_0}}$   
 (3)  $3\pi a \sqrt{\frac{ma}{KQQ_0}}$       (4)  $2\pi a \sqrt{\frac{ma}{KQQ_0}}$

Answer (2)



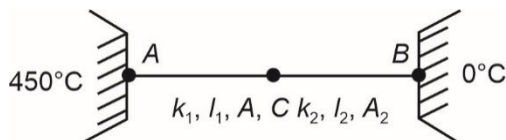
$$F_{\text{net after displacing}} = KQQ_0 \left[ \frac{1}{(a-x)^2} - \frac{1}{(a+x)^2} \right]$$

$$= \frac{KQQ_0}{(a^2 - x^2)^2} (4ax) = \frac{4KQQ_0}{a^3} x$$

$$\Rightarrow T = 2\pi a \sqrt{\frac{ma}{4KQQ_0}}$$

$$= \pi a \sqrt{\frac{ma}{KQQ_0}}$$

15. Two rods, rod 1 and rod 2 are connected in series with each other in between two reservoirs maintained at  $450^\circ\text{C}$  and  $0^\circ\text{C}$  as show. If  $\frac{k_1}{k_2} = 9$ ,  $\frac{l_1}{l_2} = 2$  and  $\frac{A_1}{A_2} = 2$  then temperature of point C is ( $k$  is thermal conductance)



- (1) 350  
 (2) 45  
 (3) 400  
 (4) 405

Answer (4)

Sol.  $\frac{R_1}{R_2} = \frac{l_1 k_2 A_2}{l_2 k_1 A_1} = 2 \times \frac{1}{9} \times \frac{1}{2} = \frac{1}{9}$

$$\frac{R_1}{R_2} = \frac{1}{9}$$

$$\Rightarrow \frac{T_A - T_C}{T_C - T_B} = \frac{1}{9}$$

Or  $9T_A + T_B = 10 T_C$

$$10T_C = 4050^\circ\text{C}$$

$$T_C = 405^\circ\text{C}$$

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.  
 22.  
 23.  
 24.  
 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. The boiling point of a 2% aqueous solution of non-volatile solute A is equal to the boiling point of 3% aqueous solution of non-volatile solute B. Find the relation between their molecular weight. [Consider both the solute as non-electrolytes]

- (1)  $M_A = 4 M_B$                       (2)  $M_B = 4 M_A$   
 (3)  $3M_A = 2M_B$                       (4)  $3M_B = 2M_A$

**Answer (3)**

**Sol.**  $(\Delta T_b)_{\text{solute A}} = \frac{2}{M_A \times 100} \times 1000 \times k_b$

$(\Delta T_b)_{\text{solute B}} = \frac{3}{M_B \times 100} \times 1000 \times k_b$

$(\Delta T_b)_A = (\Delta T_b)_B$

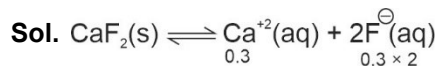
$\therefore \frac{2}{M_A} = \frac{3}{M_B}$

$2M_B = 3M_A$

2. Find out the solubility product of  $\text{CaF}_2$  if solubility of  $\text{CaF}_2$  is 2.34 g/100 ml

- (1) 0.108 (mol/L)<sup>3</sup>  
 (2) 0.072 (mol/L)<sup>3</sup>  
 (3) 0.036 (mol/L)<sup>3</sup>  
 (4) 0.054 (mol/L)<sup>3</sup>

**Answer (1)**



$K_{sp} = (0.3)(0.6)^2 \left[ S = \frac{2.34 \times 1000}{78 \times 100} = 0.3 \text{ M} \right]$

$= 0.3 \times 0.36$   
 $= 108 \times 10^{-3}$   
 $= 1.08 \times 10^{-1}$   
 $= 0.108 \text{ (mol/l)}^3$

3. Assertion :  $\text{SO}_2$  is adsorbed more easily than  $\text{CH}_4$ .  
 Reason : Molar mass of  $\text{SO}_2$  is greater than  $\text{CH}_4$  and  $\text{SO}_2$  has a non-zero dipole moment.  
 (1) Both Assertion and Reason are correct and Reason is correct explanation of Assertion  
 (2) Both Assertion and Reason are correct and Reason is not correct explanation of Assertion  
 (3) Assertion is correct, Reason is incorrect  
 (4) Assertion is incorrect, Reason is correct

**Answer (1)**

**Sol.** Assertion is correct as  $\text{SO}_2$  is adsorbed more easily than  $\text{CH}_4$ .

Reason is also correct as  $\text{SO}_2$  molecules have greater intermolecular interactions due to non-zero dipole moment as well as higher molar mass.

Hence, Reason is a correct explanation for Assertion.

4. List-I (Polymer)	List-II (Commercial name)
A. Phenol formaldehyde resin	1. Glyptal
B. Copolymer of 1,3-butadiene and Styrene	2. Novolac
C. Polymer of glycol and phthalic acid	3. Buna-S
D. Polymer of glycol and terephthalic acid	4. Dacron
(1) A(1); B(3); C(2); D(4)	
(2) A(2); B(3); C(1); D(4)	
(3) A(4); B(2); C(3); D(1)	
(4) A(3); B(4); C(2); D(1)	

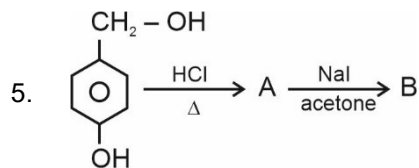
**Answer (2)**

**Sol.** Linear polymer of phenol formaldehyde is called Novolac.

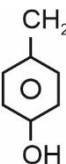
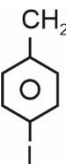
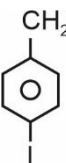
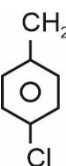
Copolymer of 1,3-butadiene and styrene is called Buna-S.

Polymer of glycol and phthalic acid is called Glyptal.

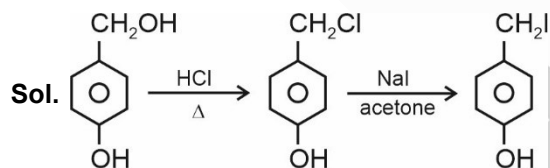
Polymer of glycol and terephthalic acid is called Dacron.



The product B is

- (1) 
- (2) 
- (3) 
- (4) 

**Answer (1)**



6. Which oxoacid has maximum oxygen atoms?

- (1) Hypophosphorous acid  
 (2) Ortho phosphoric acid  
 (3) Pyrophosphoric acid  
 (4) Orthophosphorous acid

**Answer (3)**

**Sol.** Hypophosphorous acid —  $\text{H}_3\text{PO}_2$   
 Orthophosphoric acid —  $\text{H}_3\text{PO}_4$   
 Pyrophosphoric acid —  $\text{H}_4\text{P}_2\text{O}_7$   
 Orthophosphorous acid —  $\text{H}_3\text{PO}_3$

7. Consider the following statements :

**Statement I** :  $\text{KMnO}_4$ ,  $\text{K}_2\text{Cr}_2\text{O}_7$  and  $\text{Fe}^{+3}$  can convert  $\text{I}^\ominus$  to  $\text{I}_2$  independently.

**Statement II** : Manganate ion is paramagnetic.

- (1) Statement (I) and (II), both are correct  
 (2) Statement (I) is correct and statement (II) is incorrect  
 (3) Statement (I) is incorrect and statement (II) is correct  
 (4) Both statement (I) and (II) are incorrect

**Answer (1)**

**Sol.**  $\text{KMnO}_4$  and  $\text{K}_2\text{Cr}_2\text{O}_7$  are strong oxidising agents in acidic medium and therefore, can oxidise  $\text{I}^\ominus$  to  $\text{I}_2$  easily.

$\text{Fe}^{+3}$  can also convert  $\text{I}^\ominus$  to  $\text{I}_2$  independently as

$$E^\ominus_{\text{Fe}^{+3}/\text{Fe}^{+2}} = 0.77 \text{ V}, E^\ominus_{\text{I}_2/\text{I}^\ominus} = 0.55 \text{ V}$$

Manganate ion ( $\text{MnO}_4^{2-}$ ) has  $d^1$  configuration and is therefore, paramagnetic

Therefore, both statement (I) and (II) are correct.

8. **Statement I** : The energy of electron in 2s orbital of  $\text{He}^+$  is more than that of  $\text{Li}^{2+}$

**Statement II** : The energy of an electron in an orbit decreases with increase in atomic number

- (1) Both the statements are correct and statement II is correct explanation of statement I  
 (2) Both the statements are correct but statement II is not the correct explanation of statement I  
 (3) Statement I is true but statement II is false  
 (4) Statement I is false but statement II is true

**Answer (1)**

**Sol.** The energy of electron in  $n^{\text{th}}$  orbit of a single electron species is given by

$$E_n = -13.6 \frac{Z^2}{n^2} \text{ eV}$$

For 2s orbital of  $\text{He}^+$  ion,

$$E_2 = -13.6 \frac{(2)^2}{(2)^2} = -13.6 \text{ eV}$$

For 2s orbital of  $\text{Li}^{2+}$  ion,

$$E'_2 = -13.6 \frac{(3)^2}{(2)^2} = -30.6 \text{ eV}$$

$$\therefore E'_2 < E_2$$

Both the statements are correct and statement II is the correct explanation of statement I.

9. 250 g of a solution (aqueous) contains D-glucose. The % of C (by mass) present in the solution is 16.7. Find the molality of the solution.

- (1) 2.56 m  
(2) 3.98 m  
(3) 3.24 m  
(4) 1.78 m

**Answer (2)**

**Sol.** Mass of C =  $\frac{16.7}{100} \times 250 = 41.75 \text{ g}$

$$\therefore \text{Mass of D-Glucose} = 41.75 \times \frac{180}{72} = 104.375 \text{ g}$$

Mass of solvent = 145.625 g

$$\text{Molality} = \frac{104.375}{180 \times 145.625} \times 1000 = 3.98 \text{ m}$$

10. Match List-I consisting of pollutant to List-II consisting of disease.

**List-I**

- (A) Sulphate > 500 ppm  
(B) Nitrate > 50 ppm  
(C) Lead > 50 ppb  
(D) Fluoride > 2 ppm

**List-II**

- (P) Methemoglobinemia  
(Q) Mottling of teeth  
(R) Laxative effect  
(S) Kidney Damage

- (1) A – P; B – Q; C – R; D – S  
(2) A – R; B – P; C – S; D – Q  
(3) A – Q; B – R; C – P; D – S  
(4) A – Q; B – R; C – S; D – P

**Answer (2)**

**Sol.** Presence of sulphate in drinking water above 500 ppm causes laxative effect.

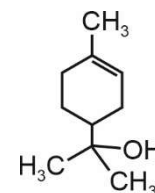
Presence of nitrate in drinking water above 50 ppm causes methemoglobinemia whereas presence of lead and fluoride greater than 50 ppb and 2 ppm (respectively) would cause damage to kidney and mottling of teeth respectively.

11. Match the structures given in Column-II with the class to which they belong in Column-I

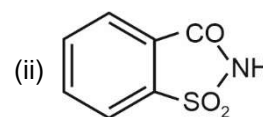
**Column-I**

**Column-II**

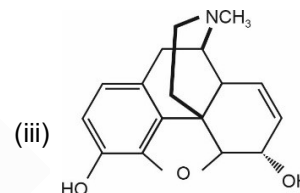
- (A) Artificial sweetener (i)



- (B) Antiseptic (ii)



- (C) Narcotics (iii)

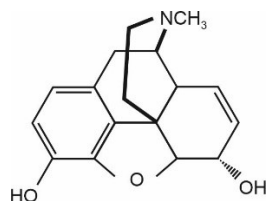


- (1) A – i  
B – ii  
C – iii  
(2) A – i  
B – iii  
C – ii  
(3) A – ii  
B – i  
C – iii  
(4) A – iii  
B – ii  
C – i

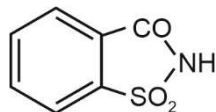
**Answer (3)**

**Sol.** is Terpineol used as an antiseptic





is Morphine, a narcotic analgesic



is saccharin used as an artificial sweetener

12. **Assertion** : Hydrogen peroxide can act both as an oxidising agent as well as reducing agent in acidic as well as basic medium

**Reason** : Density of  $\text{H}_2\text{O}_2$  is less than that of  $\text{D}_2\text{O}$

- (1) Both Assertion and Reason are correct  
 (2) Assertion is correct and Reason is false  
 (3) Assertion is false and Reason is correct  
 (4) Both Assertion and Reason are false

**Answer (2)**

**Sol.** Hydrogen peroxide acts as an oxidising as well as reducing agent in both acidic and basic medium. So, Assertion is correct.

Density of  $\text{H}_2\text{O}_2$  is 1.44 gm/cc and that of  $\text{D}_2\text{O}$  is 1.106 gm/cc at 298 K. So, Reason is false.

- | 13. Column-I  | Column-II  |
|---|--|
| (i) $\text{C}_6\text{H}_5\text{SO}_2\text{Cl}$                      | (P) Hinsberg reagent                                 |
| (ii) $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$ | (Q) Can give carbylamine reaction                    |
| (iii) $\text{CH}_3-\text{NH}_2$                                     | (R) Can give Hoffmann bromamide degradation reaction |

Match Column-I with Column-II.

- (1) (i)-(P), (ii)-(Q), (iii)-(R)  
 (2) (i)-(P), (ii)-(R), (iii)-(Q)  
 (3) (i)-(R), (ii)-(Q), (iii)-(P)  
 (4) (i)-(R), (ii)-(P), (iii)-(Q)

**Answer (2)**

**Sol.** •  $\text{C}_6\text{H}_5\text{SO}_2\text{Cl}$  is used as Hinsberg reagent.

- $\text{R}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$  (Amides) can give Hoffmann bromamide degradation.
- Primary amines can give carbylamine reaction.

14. Which of the following are not methods of purification of metal?

- (a) Poling (b) Electrolysis  
 (c) Liquefaction (d) Leaching  
 (e) Calcination (f) Distillation  
 (1) (a), (b) and (c) (2) (b), (d) and (f)  
 (3) (d) and (f) (4) (d) and (e)

**Answer (4)**

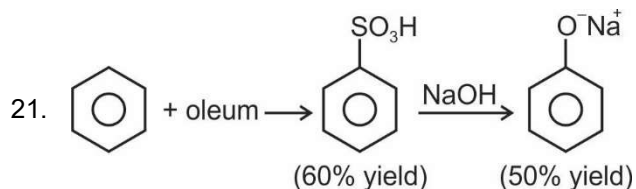
**Sol.** (a) Poling, (b) electrolysis, (c) liquefaction and (f) distillation are methods used to obtain metals of high purity from crude metals contaminated with some impurity.

(d) leaching and (e) calcination are methods used for concentration of ores. They are not used for purification of metals.

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.



The % yield of the complete reaction is

**Answer (30.00)**

**Sol.** The % yield of the complete reaction is

$$0.6 \times 0.5 \times 100 = 30\%$$

22. Find out the number of paramagnetic species  $\text{KO}_2$ ,  $\text{Na}_2\text{O}$ ,  $\text{NO}$ ,  $\text{NO}_2$ ,  $\text{N}_2\text{O}_3$ ,  $\text{Cl}_2\text{O}$ ,  $\text{SO}_2$ ,  $\text{SO}_3$

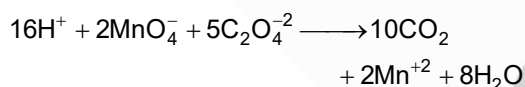
**Answer (03.00)**

**Sol.** Paramagnetic species are,  $\text{KO}_2$ ,  $\text{NO}$  and  $\text{NO}_2$  whereas diamagnetic species are  $\text{Na}_2\text{O}$ ,  $\text{N}_2\text{O}_3$ ,  $\text{Cl}_2\text{O}$ ,  $\text{SO}_2$  and  $\text{SO}_3$

23. In the titration of  $\text{KMnO}_4$  and oxalic acid in acidic medium, the oxidation number of carbon in the carbon containing product formed at the end is

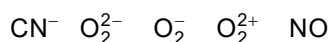
**Answer (04.00)**

**Sol.** During titration of  $\text{KMnO}_4$  with oxalic acid in acidic medium, oxalic acid ( $\text{H}_2\text{C}_2\text{O}_4$ ) is oxidised to  $\text{CO}_2$



The oxidation number of C in  $\text{CO}_2$  is +4

24. Find out the number of species having similar bond order.



**Answer (02.00)**

**Sol.**  $\text{O}_2^{2+}$  and  $\text{CN}^-$  have a bond order of 3

$\text{NO}$  has a bond order of 2.5

$\text{O}_2^{2-}$  and  $\text{O}_2^-$  have a bond order of 1 and 1.5 respectively.

25. 10 ml of  $\text{Fe}^{+2}$  ions react completely with 20 ml of 0.02 M acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  solution. Find the molarity of  $\text{Fe}^{+2}$  ions.

**Answer (00.24)**

**Sol.** Applying the law of equivalence

milliequivalents of  $\text{Fe}^{+2}$

$$= \text{milliequivalents of } \text{K}_2\text{Cr}_2\text{O}_7$$

$$10 \times M \times 1 = 20 \times 0.02 \times 6$$

$$M = \frac{2.4}{10}$$

Molarity = 0.24 M

26. Number of basic oxides among the following compounds is

$\text{NO}_2$ ,  $\text{N}_2\text{O}$ ,  $\text{NO}$ ,  $\text{Li}_2\text{O}$ ,  $\text{SO}_2$ ,  $\text{PbO}$

**Answer (01.00)**

**Sol.**  $\text{NO}_2$  – acidic  
 $\text{N}_2\text{O}$  – neutral  
 $\text{NO}$  – neutral  
 $\text{Li}_2\text{O}$  – basic  
 $\text{SO}_2$  – acidic  
 $\text{PbO}$  – amphoteric

27. A radioactive substance takes 30 years to be reduced to  $\frac{1}{16}$ th of its original concentration. Find half life of substance (in years)

**Answer (07.50)**

**Sol.** As the decomposition is a first order reaction, we have

$$\text{Amount left after } n \text{ half-lives} = \frac{[A]_0}{2^n}$$

where n represents the number of half lives &  $[A]_0$  represents initial concentration/activity.

$$\text{As } \frac{[A]_0}{2^n} = \frac{[A]_0}{16} \Rightarrow n = 4$$

This means 30 years includes four half lives.

$$\therefore \text{Half life} = \frac{30}{4} = 7.5 \text{ years}$$

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 :**

- Let  $a_1, a_2, a_3, \dots, a_n$  be in A.P. The ratio of sum of first five terms to the sum of first 9 terms is 5 : 17. Also  $110 < a_{15} < 120$ . Find the sum of first 10 terms of the A.P. (where all  $a_i (i = 1, 2, \dots, n)$  are integers)
 

(1) 330	(2) 460
(3) 290	(4) 380

**Answer (4)**

**Sol.** Let first term is 'a' & common difference is 'd' for the given AP.

$$\frac{S_5}{S_9} = \frac{5}{17}$$

$$\frac{\frac{5}{2}(2a + 4d)}{\frac{9}{2}(2a + 8d)} = \frac{5}{17}$$

Therefore  $4a = d$

$$a_{15} = a + 14d = 57a$$

It is given that  $110 < a_{15} < 120$

$$\Rightarrow 110 < 57a < 120$$

For integral terms of the AP,  $a = 2$

Sum of 10 terms of AP

$$S_{10} = \frac{10}{2}(4 + 9 \times 8) = 380$$

- Let  $S$  be sample space for 5 digit number if  $P$  is probability of a number being randomly selected which is multiple of 7 but not divisible by 5 then  $9P$  is equal to
 

(1) 1.0146	(2) 1.2085
(3) 1.0285	(4) 1.1521

**Answer (3)**

**Sol.** Five digit number lie from 10000 to 99999

$$\therefore S = 90000$$

Numbers divisible by 7 =  $\frac{90000}{7}$

& number divisible by 7 & not multiple of

$$S = \frac{90000}{35}$$

$$\therefore \text{Required Probability} = \frac{90000 - \frac{90000}{35}}{90000}$$

$$\Rightarrow P = \frac{4}{35}$$

$$\therefore 9P = \frac{36}{35} = 1.02857$$

- Let  $A = \begin{bmatrix} 1 & 2 \\ -2 & -5 \end{bmatrix}$ ,  $\alpha$  and  $\beta$  belongs to real numbers such that  $\alpha A^2 + \beta A = 2I$ , where  $I$  is an identify matrix of order  $2 \times 2$ , then value of  $\alpha + \beta$  is equal to
 

(1) -10	(2) -6
(3) 6	(4) 10

**Answer (4)**

**Sol.**  $A = \begin{bmatrix} 1 & 2 \\ -2 & -5 \end{bmatrix}$

$$A^2 = \begin{bmatrix} 1 & 2 \\ -2 & -5 \end{bmatrix} \begin{bmatrix} 1 & 2 \\ -2 & -5 \end{bmatrix} = \begin{bmatrix} -3 & -8 \\ 8 & 21 \end{bmatrix}$$

It is given that

$$\alpha A^2 + \beta A = 2I$$

$$\alpha \begin{bmatrix} -3 & -8 \\ 8 & 21 \end{bmatrix} + \beta \begin{bmatrix} 1 & 2 \\ -2 & -5 \end{bmatrix} = 2 \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$-3\alpha + \beta = 2 \text{ and } -8\alpha + 2\beta = 0$$

$$\alpha = 2, \beta = 8$$

$$\alpha + \beta = 10$$

- $(p \wedge r) \Leftrightarrow (p \wedge \sim q)$  which is equivalent to  $\sim p$ . Then  $r$  will be
 

(1) $p$	(2) $\sim p$
(3) $q$	(4) $\sim q$

**Answer (3)**

Sol. The truth table

$p$	$q$	$\sim p$	$\sim q$	$p \wedge q$	$p \wedge \sim q$	$p \wedge q \Leftrightarrow p \wedge \sim q$
T	T	F	F	T	F	F
T	F	F	T	F	T	F
F	T	T	F	F	F	T
F	F	T	T	F	F	T

Clearly  $p \wedge q \Leftrightarrow p \wedge \sim q \equiv \sim p$

$$\therefore r = q$$

5. The remainder of  $(2021)^{2022} + (2022)^{2021}$  when divided by 7 is

- (1) 0 (2) 1  
(3) 2 (4) 6

**Answer (1)**

Sol. Let  $S = (2021)^{2022} + (2022)^{2021}$

$$= (2023 - 2)^{2022} + (2023 - 1)^{2021}$$

$$= 7K_1 + 2^{2022} + 7K_2 - 1$$

$$= 7(K_1 + K_2) + 8^{674} - 1$$

$$= 7(K_1 + K_2) + (7 + 1)^{674} - 1$$

$$= 7(K_1 + K_2) + 7K_3 + 1 - 1$$

$$= 7(K_1 + K_2 + K_3)$$

Therefore, S is divisible by 7.

6. Let  $R_1$  and  $R_2$  be two relation defined on  $R$  by  $aR_1b : ab \geq 0$  and  $aR_2b \Leftrightarrow b \geq a, a, b \in R$  then the correct statement is :

- (1) Both  $R_1$  and  $R_2$  are equivalence relations  
(2)  $R_1$  is equivalence but  $R_2$  is not  
(3)  $R_2$  is equivalence but  $R_1$  is not  
(4) Both  $R_1$  and  $R_2$  are not equivalence relations

**Answer (4)**

Sol.  $R_1 \equiv \{ab \geq 0, a, b \in R\}$

for  $\forall(x, x)$  we have  $x^2 \geq 0$

Also if  $xy \geq 0 \Rightarrow x$  &  $y$  of same sign i.e.,  $yx \geq 0$

& if  $xy \geq 0 \Rightarrow x, y$  are of same sign

$yz \geq 0 \Rightarrow y, z$  are of same sign (but not holds if  $y = 0$ )

$\therefore R_1$  is reflexive, symmetric but not transitive

But for  $R_2$  if  $a > b$  then  $b \not\geq a$  for  $\forall x \in R$

7.  $\cos \frac{2\pi}{7} + \cos \frac{4\pi}{7} + \cos \frac{6\pi}{7}$  equals

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

**Answer (2)**

Sol.  $\cos \frac{2\pi}{7} + \cos \frac{4\pi}{7} + \cos \frac{6\pi}{7}$

Using cosine - series

$$\Rightarrow \frac{\sin\left(3\left(\frac{\pi}{7}\right)\right)}{\sin\left(\frac{\pi}{7}\right)} \cdot \cos\left(\frac{4\pi}{7}\right)$$

$$\Rightarrow \frac{\sin\left(\frac{3\pi}{7}\right)\cos\left(\frac{4\pi}{7}\right)}{\sin\frac{\pi}{7}}$$

Using allied angles

$$\frac{-\sin\left(\frac{\pi}{14}\right) \cdot \cos\left(\frac{\pi}{14}\right)}{\sin\frac{\pi}{7}}$$

$$\Rightarrow \frac{-2\sin\left(\frac{\pi}{14}\right)\cos\left(\frac{\pi}{14}\right)}{2\sin\frac{\pi}{7}} = \frac{-1\sin\frac{\pi}{7}}{2\sin\frac{\pi}{7}} = \frac{-1}{2}$$

8. If  $\int \frac{(x^2 + 1)e^x}{(x+1)^2} dx = e^x f(x)$ . Then  $\frac{d^3f}{dx^3}$  at  $x = 1$  is

equal to

- (1)  $\frac{1}{4}$  (2)  $\frac{3}{4}$   
(3)  $\frac{1}{2}$  (4)  $\frac{1}{8}$

**Answer (2)**

Sol.  $\int \frac{(x^2 + 1)e^x}{(x+1)^2} dx = \int \frac{(x+1)^2 e^x}{(x+1)^2} dx - \int \frac{2xe^x}{(x+1)^2} dx$

$$= \int e^x dx - 2 \int e^x \left( \frac{1}{x+1} - \frac{1}{(x+1)^2} \right) dx$$

$$= e^x - 2 \frac{e^x}{x+1} + c$$

$$= e^x \left( \frac{x-1}{x+1} \right) + c$$

Therefore  $f(x) = \frac{x-1}{x+1}$

$$\frac{df}{dx} = \frac{2}{(x+1)^2}, \quad \frac{d^2f}{dx^2} = \frac{-4}{(x+1)^3}, \quad \frac{d^3f}{dx^3} = \frac{12}{(x+1)^4}$$

$$\frac{d^3f}{dx^3} \Big|_{x=1} = \frac{12}{16} = \frac{3}{4}$$

9. If  $\lim_{x \rightarrow 7} \frac{18 - [1-x]}{[x] - 3a}$  exist then a is equal to

- (1) -6                                      (2) 6  
 (3) 7                                        (4) -8

**Answer (1)**

**Sol.**  $\lim_{x \rightarrow 7} \frac{18 - [1-x]}{[x] - 3a} = \lim_{x \rightarrow 7} \frac{17 - [-x]}{[x] - 3a}$

$$\lim_{x \rightarrow 7} \frac{17 - [-x]}{[x] - 3a} = \frac{24}{6 - 3a}$$

$$\& \lim_{x \rightarrow 7} \frac{17 - [-x]}{[x] - 3a} = \frac{25}{7 - 3a}$$

For limit to exist

$$\frac{24}{6 - 3a} = \frac{25}{7 - 3a}$$

$$\Rightarrow 168 - 72a = 150 - 75a$$

$$\Rightarrow 3a = -18$$

$$\Rightarrow a = -6$$

10. If  $\begin{bmatrix} 14 & 28 & -14 \\ -14 & 14 & 28 \\ 28 & -14 & 14 \end{bmatrix} = \text{adj}(\text{adj}(A))$ , then  $|A|$  is equal

to

- (1) 14                                       (2) -14  
 (3) 28                                      (4) -28

**Answer (1)**

**Sol.**  $|\text{adj}(\text{adj}(A))| = |A|^4$  (as  $A$  is  $3 \times 3$  determinate)

$$\therefore |A|^4 = \begin{vmatrix} 14 & 28 & -14 \\ -14 & 14 & 28 \\ 28 & -14 & 14 \end{vmatrix}$$

$$\Rightarrow |A|^4 = 14^4$$

11. If two curves  $y = y_1(x)$  and  $y = y_2(x)$  satisfying differential equation  $\frac{dy}{dx} = x + y$ , for which  $y_1(0) = 0$  and  $y_2(0) = 1$  then number of point of intersection of these two curves are

- (1) 2    (2) 0  
 (3) 3    (4) 1

**Answer (2)**

**Sol.**  $\frac{dy}{dx} = x + y$

$$\text{Let } x + y = t \Rightarrow 1 + \frac{dy}{dx} = \frac{dt}{dx}$$

$$\frac{dt}{dx} - 1 = t$$

$$\frac{dt}{t+1} = dx$$

$$\ln |t+1| = x + c_0$$

$$|t+1| = ce^x$$

$$|x + y + 1| = ce^x$$

$$y_1(0) = 0 \Rightarrow y_1(x) \text{ is given by } |x + y + 1| = e^x$$

$$y_2(0) = 1 \Rightarrow y_2(x) \text{ is given by } |x + y + 1| = 2e^x$$

No intersection

12. Number of all  $3 \times 3$  matrices formed by  $\{1, -1, 0\}$  such that trace  $(AA^T) = 6$ , is

- (1)  ${}^9C_3 \cdot 2^6$                                       (2)  ${}^8C_3 \cdot 2^7$   
 (3)  ${}^9C_4 \cdot 2^9$                                       (4)  $3^9$

**Answer (1)**

**Sol.** Let  $A = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}$  then  $A^T = \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix}$

then  $\text{Tr.}(A \cdot A^T)$

$$= a_1^2 + b_1^2 + c_1^2 + a_2^2 + b_2^2 + c_2^2 + a_3^2 + b_3^2 + c_3^2$$

= sum of square of all elements.

$$\therefore a_1^2 + b_1^2 + c_1^2 + a_2^2 + b_2^2 + c_2^2 + a_3^2 + b_3^2 + c_3^2 = 6$$

Three of the elements are zero and remaining 6 are +1 or -1,

$\therefore$  Total number of possible matrices

$$= {}^9C_3 \cdot 6$$

- 13.
- 14.
- 15.
- 16.
- 17.
- 18.
- 19.
- 20.

⇒ |A| = 14 **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  $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$  satisfies  $\left(4\sqrt{\frac{2}{5}}, 3\right)$  and  $e = \frac{1}{4}$ , then

$a^2 + b^2$  is equal to

**Answer (31)**

**Sol.**  $e = \frac{1}{4} = \sqrt{1 - \frac{b^2}{a^2}} \Rightarrow \frac{b^2}{a^2} = \frac{15}{16}$

⇒  $16 \times b^2 = 15a^2$  ... (i)

and  $\frac{16.2}{5a^2} + \frac{9}{b^2} = 1$  ... (ii)

⇒  $\frac{16.2}{16.b^2} \cdot 3 + \frac{9}{b^2} = 1$

⇒  $\frac{15}{b^2} = 1 \Rightarrow b^2 = 15$  and  $a^2 = 16$

∴  $a^2 + b^2 = 31$

22. The number of points where tangents are vertical or horizontal to curve  $y^5 + 9xy - 2x = 0$  are equal to

**Answer (03)**

**Sol.**  $y^5 + 9xy - 2x = 0$

Differentiate w.r.t. x

$5y^4 \frac{dy}{dx} + 9x \frac{dy}{dx} + 9y - 2 = 0$

$\frac{dy}{dx} = \frac{2 - 9y}{5y^4 + 9x}$

For horizontal tangents,  $\frac{dy}{dx} = 0 \Rightarrow y = \frac{2}{9}$

For vertical tangents,  $\frac{dx}{dy} = 0 \Rightarrow 5y^4 + 9x = 0$

$x = -\frac{5}{9}y^4$

$y^5 - 5y^5 + \frac{10}{9}y^4 = 0$

$4y^5 = \frac{10}{9}y^4 \Rightarrow y = 0, \frac{5}{9}$

23. If the coefficient of  $x^{10}$  in  $\left(\frac{\sqrt{x}}{5^{1/4}} + \frac{\sqrt{5}}{x^{1/3}}\right)^{100}$  is  $5^n \cdot l$

(where l is not a multiple of 5), then n equals

**Answer (13)**

**Sol.**  $T_{r+1} = {}^{100}C_r \left(\frac{\sqrt{x}}{5^{1/4}}\right)^{100-r} \left(\frac{\sqrt{5}}{x^{1/3}}\right)^r$

For  $x^{10}$   $\frac{100-r}{2} - \frac{r}{3} = 10$

⇒  $300 - 5r = 60$

⇒  $r = 48$

∴ Coefficients of  $x^{10} = \frac{{}^{100}C_{48}}{5^{13}} \cdot 5^{24}$

$= {}^{100}C_{48} \cdot 5^{11}$

Exponent of 5 in

${}^{100}C_{48} = (20+4) - (10+2) - (9+1)$   
 $= 2^n$

∴ Coefficients of  $x^{10} = 5^{13} \cdot l$

⇒  $n = 13$

24. Let  $S = \{z \in \mathbb{C} : z^2 + \bar{z} = 0\}$  then  $\sum (\text{Re}(z) + \text{Im}(z))$  is equal to  $z \in S$

**Answer (00)**

**Sol.** Let  $z = a + ib$

$(a + ib)^2 + (a - ib) = 0$

$a^2 - b^2 + a = 0$  and  $2ab - b = 0$

⇒  $b = 0$  or  $a = \frac{1}{2}$

If  $b = 0$ ;  $a = 0, -1$

$$\text{If } a = \frac{1}{2}; \quad b = \pm \frac{\sqrt{3}}{2}$$

$$\sum (\text{Re}(z) + \text{Im}(z)) = (0+0) + (-1+0)$$

$$+ \left( \frac{1}{2} + \frac{\sqrt{3}}{2} \right) + \left( \frac{1}{2} - \frac{\sqrt{3}}{2} \right)$$

$$= 0$$

25.

26.

27.

28.

29.

30.

