

# JEE (Main) CHEMISTRY SOLVED PAPER

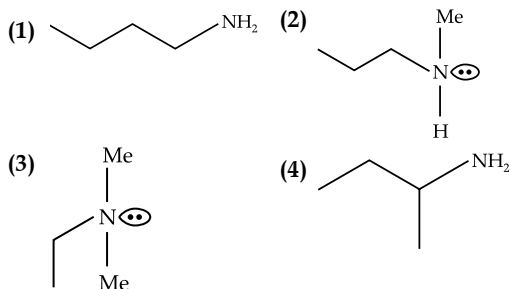
2023  
31<sup>st</sup> Jan. Shift 2

## Section A

- Q. 1.** Which one of the following statements is incorrect?
- (1) Van Arkel method is used to purify tungsten.
  - (2) The malleable iron is prepared from cast iron by oxidising impurities in a reverberatory furnace.
  - (3) Cast iron is obtained by melting pig iron with scrap iron and coke using hot air blast.
  - (4) Boron and Indium can be purified by zone refining method.
- Q. 2.** Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).  
**Assertion (A):** The first ionization enthalpy of 3d series elements is more than that of group 2 metals  
**Reason (R):** In 3d series of elements successive filling of d-orbitals takes place.  
In the light of the above statements, choose the correct answer from the options given below:
- (1) Both (A) and (R) are true but (R) is not the correct explanation of (A)
  - (2) Both (A) and (R) are true and (R) is the correct explanation of (A)
  - (3) (A) is true but (R) is false
  - (4) (A) is false but (R) is true
- Q. 3.** Given below are two statements:  
**Statement I:**  $\text{H}_2\text{O}_2$  is used in the synthesis of Cephalosporin  
**Statement II:**  $\text{H}_2\text{O}_2$  is used for the restoration of aerobic conditions to sewage wastes.  
In the light of the above statements, choose the most appropriate answer from the options given below:
- (1) Both Statement I and Statement II are incorrect
  - (2) Statement I is incorrect but Statement II is correct
  - (3) Statement I is correct but Statement II is incorrect
  - (4) Both Statement I and Statement II are correct
- Q. 4.** A hydrocarbon 'X' with formula  $\text{C}_6\text{H}_8$  uses two moles  $\text{H}_2$  on catalytic hydrogenation of its one mole. On ozonolysis, 'X' yields two moles of methane dicarbaldehyde. The hydrocarbon 'X' is:
- (1) cyclohexa-1, 4-diene
  - (2) cyclohexa-1, 3-diene
  - (3) 1-methylcyclopenta-1, 4-diene
  - (4) hexa-1, 3, 5-triene
- Q. 5.** Evaluate the following statements for their correctness.
- A. The elevation in boiling point, temperature of water will be same for 0.1M NaCl and 0.1M urea.
- B. Azeotropic mixtures boil without change in their composition.
- C. Osmosis always takes place from hypertonic to hypotonic solution.
- D. The density of 32%  $\text{H}_2\text{SO}_4$  solution having molarity 4.09M is approximately  $1.26 \text{ g mL}^{-1}$ .
- E. A negatively charged sol is obtained when KI solution is added to silver nitrate solution.
- Choose the correct answer from the options given below:
- (1) A, B and D only
  - (2) B and D only
  - (3) B, D and E only
  - (4) A and C only
- Q. 6.** The Lewis acid character of boron tri halides follows the order:
- (1)  $\text{BI}_3 > \text{BBr}_3 > \text{BCl}_3 > \text{BF}_3$
  - (2)  $\text{BBr}_3 > \text{BI}_3 > \text{BCl}_3 > \text{BF}_3$
  - (3)  $\text{BCl}_3 > \text{BF}_3 > \text{BBr}_3 > \text{BI}_3$
  - (4)  $\text{BF}_3 > \text{BCl}_3 > \text{BBr}_3 > \text{BI}_3$
- Q. 7.** When a hydrocarbon A undergoes complete combustion it requires 11 equivalents of oxygen and produces 4 equivalents of water. What is the molecular formula of A?
- (1)  $\text{C}_5\text{H}_8$
  - (2)  $\text{C}_{11}\text{H}_4$
  - (3)  $\text{C}_9\text{H}_8$
  - (4)  $\text{C}_{11}\text{H}_8$
- Q. 8.** Arrange the following orbitals in decreasing order of energy.
- A.  $n = 3, l = 0, m = 0$     B.  $n = 4, l = 0, m = 0$   
C.  $n = 3, l = 1, m = 0$     D.  $n = 3, l = 2, m = 1$
- The correct option for the order is:
- (1)  $D > B > C > A$
  - (2)  $D > B > A > C$
  - (3)  $A > C > B > D$
  - (4)  $B > D > C > A$
- Q. 9.** The element playing significant role in neuromuscular function and interneuronal transmission is:
- (1) Li
  - (2) Mg
  - (3) Be
  - (4) Ca
- Q. 10.** Given below are two statements:  
**Statement I:** Upon heating a borax bead dipped in cupric sulphate in a luminous flame, the colour of the bead becomes green  
**Statement II:** The green colour observed is due to the formation of copper(I) metaborate  
In the light of the above statements, choose the most appropriate answer from the options given below:
- (1) Both Statement I and Statement II are true
  - (2) Statement I is true but Statement II is false
  - (3) Statement I is false but Statement II is true
  - (4) Both Statement I and Statement II are false
- Q. 11.** Which of the following compounds are not used as disinfectants?
- A. Chloroxylenol    B. Bithional  
C. Veronal    D. Prontosil  
E. Terpeneol
- Choose the correct answer from the options given below:
- (1) C, D
  - (2) B, D, E
  - (3) A, B
  - (4) A, B, E
- Q. 12.** Incorrect statement for the use of indicators in acid – base titration is:

- (1) Methyl orange may be used for a weak acid vs weak base titration.  
 (2) Phenolphthalein is a suitable indicator for a weak acid vs strong base titration.  
 (3) Methyl orange is a suitable indicator for a strong acid vs weak base titration.  
 (4) Phenolphthalein may be used for a strong acid vs strong base titration.

**Q. 13.** An organic compound  $[A](C_4H_{11}N)$ , shows optical activity and gives  $N_2$  gas on treatment with  $HNO_2$ . The compound  $[A]$  reacts with  $PhSO_2Cl$  producing a compound which is soluble in  $KOH$ .



**Q. 14.** The normal rain water is slightly acidic and its pH value is 5.6 because of which one of the following?

- (1)  $CO_2 + H_2O \rightarrow H_2CO_3$   
 (2)  $2SO_2 + O_2 + 2H_2O \rightarrow 2H_2SO_4$   
 (3)  $4NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$   
 (4)  $N_2O_5 + H_2O \rightarrow 2HNO_3$

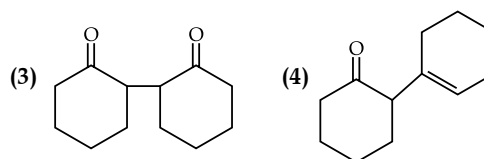
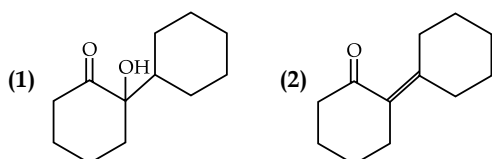
**Q. 15.** Match List I with List II

LIST I		LIST II	
A.	Physisorption	I.	Single Layer Adsorption
B.	Chemisorption	II.	$20 - 40 \text{ kJ mol}^{-1}$
C.	$N_2(g) + 3H_2(g) \xrightarrow{Fe(s)} 2NH_3(g)$	III.	Chromatography
D.	Analytical Application of Adsorption	IV.	Heterogeneous catalysis

Choose the correct answer from the options given below:

- (1) A - II, B - I, C - IV, D - III  
 (2) A - IV, B - II, C - III, D - I  
 (3) A - II, B - III, C - I, D - IV  
 (4) A - III, B - IV, C - I, D - II

**Q. 16.** Cyclohexylamine when treated with nitrous acid yields (P). On treating (P) with PCC results in (Q). When (Q) is heated with dil.  $NaOH$  we get (R). The final product (R) is:



**Q. 17.** In the following halogenated organic compounds the one with maximum number of chlorine atoms in its structure is:

- (1) Freon - 12 (2) Gammexene  
 (3) Chloropicrin (4) Chloral

**Q. 18.** In Dumas method for the estimation of  $N_2$ , the sample is heated with copper oxide and the gas evolved is passed over:

- (1) Copper oxide (2) Ni  
 (3) Pd (4) Copper gauze

**Q. 19.** Which of the following elements have half-filled  $f$ -orbitals in their ground state?

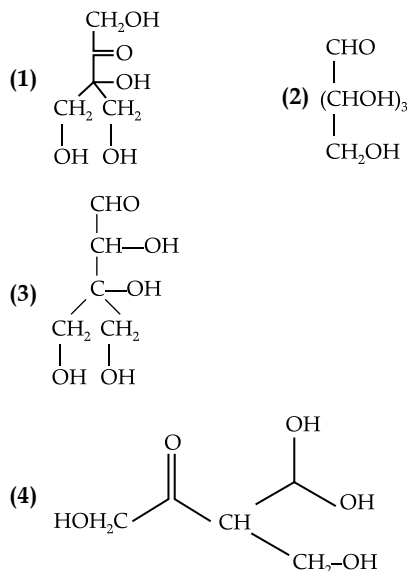
(Given: atomic number Sm = 62; Eu = 63; Tb = 65; Gd = 64, Pm = 61)

- A. Sm B. B.Eu C. Tb D. Gd  
 E. Pm

Choose the correct answer from the options given below:

- (1) A and B only (2) A and E only  
 (3) C and D only (4) B and D only

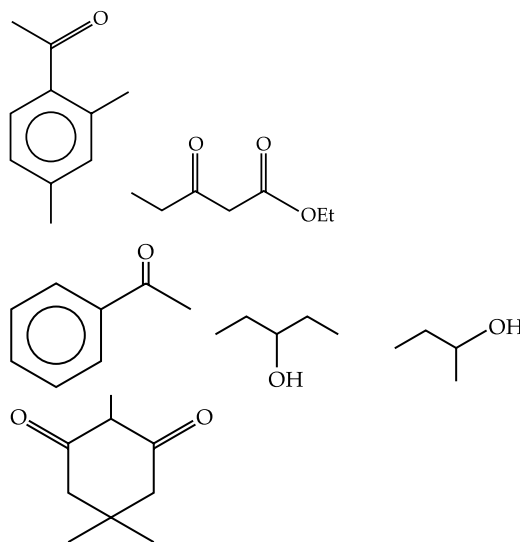
**Q. 20.** Compound A,  $C_5H_{10}O_5$ , given a tetraacetate with  $Ac_2O$  and oxidation of A with  $Br_2-H_2O$  gives an acid,  $C_5H_{10}O_6$ . Reduction of A with HI gives isopentane. The possible structure of A is:



### Section B

**Q. 21.** The rate constant for a first order reaction is  $20 \text{ min}^{-1}$ . The time required for the initial concentration of the reactant to reduce to its  $\frac{1}{32}$  level is  $\underline{\hspace{2cm}} 10^{-2} \text{ min}$ . (Nearest integer)  
 (Given:  $\ln 10 = 2.303$   
 $\log 2 = 0.3010$ )

- Q. 22. Enthalpies of formation of  $\text{CCl}_4$  (g),  $\text{H}_2\text{O}$  (g),  $\text{CO}_2$  (g) and  $\text{HCl}$  (g) are  $-105$ ,  $-242$ ,  $-394$  and  $-92$   $\text{kJ mol}^{-1}$  respectively. The magnitude of enthalpy of the reaction given below is  $\text{kJ mol}^{-1}$ . (nearest integer) together  
 $\text{CCl}_4$  (g) +  $2\text{H}_2\text{O}$  (g)  $\rightarrow$   $\text{CO}_2$  (g) +  $4\text{HCl}$  (g)
- Q. 23. A sample of a metal oxide has formula  $\text{M}_{0.83}\text{O}_{1.00}$ . The metal M can exist in two oxidation states + 2 and + 3. In the sample of  $\text{M}_{0.83}\text{O}_{1.00}$ , the percentage of metal ions existing in + 2 oxidation state is %. (nearest integer)
- Q. 24. The resistivity of a 0.8M solution of an electrolyte is  $5 \times 10^{-3} \Omega \text{cm}$ . Its molar conductivity is  $\times 10^4 \Omega^{-1} \text{cm}^2 \text{mol}^{-1}$  (Nearest integer)
- Q. 25. At 298 K, the solubility of silver chloride in water is  $1.434 \times 10^{-3} \text{g L}^{-1}$ . The value of  $-\log K_{\text{sp}}$  for silver chloride is (Given mass of Ag is  $107.9 \text{g mol}^{-1}$  and mass of Cl is  $35.5 \text{g mol}^{-1}$ )
- Q. 26. If the CFSE of  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  is  $-96.0 \text{kJ/mol}$ , this complex will absorb maximum wavelength at nm. (nearest integer)  
 Assume Planck's constant ( $h$ ) =  $6.4 \times 10^{-34} \text{Js}$ ,  
 Speed of light ( $c$ ) =  $3.0 \times 10^8 \text{m/s}$  and Avogadro's Constant ( $N_A$ ) =  $6 \times 10^{23}/\text{mol}$
- Q. 27. The number of alkali metal(s), from Li, K, Cs, Rb having ionization enthalpy greater than  $400 \text{kJ mol}^{-1}$  and forming stable super oxide is
- Q. 28. The number of molecules which gives haloform test among the following molecules is



- Q. 29. Assume carbon burns according to following equation:  $2\text{C}_{(s)} + \text{O}_{2(g)} \rightarrow 2\text{CO}_{(g)}$   
 When 12 g carbon is burnt in 48 g of oxygen, the volume of carbon monoxide produced is  $\times 10^{-1} \text{L}$  at STP [ nearest integer ]  
 [Given: Assume CO as ideal gas, Mass of C is  $12 \text{g mol}^{-1}$ , Mass of O is  $16 \text{g mol}^{-1}$  and molar volume of an ideal gas at STP is  $22.7 \text{L mol}^{-1}$ ]
- Q. 30. Amongst the following, the number of species having the linear shape is  
 $\text{XeF}_2$ ,  $\text{I}_3^+$ ,  $\text{C}_3\text{O}_2$ ,  $\text{CO}_2$ ,  $\text{BeCl}_2$

## Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(1)	Metallurgical operation	Metallurgy
2	(1)	Ionization enthalpy	Periodic classification of elements
3	(4)	Properties of hydrogen peroxide	Hydrogen
4	(1)	Properties of hydrocarbons	Hydrocarbon
5	(2)	Colligative properties	Liquid solution
6	(1)	Lewis acid character	Chemical bonding
7	(3)	Combustion of hydrocarbons	Hydrocarbon
8	(1)	Energy of orbits	Structure of atom
9	(4)	Biological significance of metals	s block
10	(4)	Properties of Boron oxide	p block
11	(1)	Disinfectant	Chemistry in everyday life
12	(1)	Types of indicator	Ionic equilibrium
13	(4)	Properties of nitrogen containing compounds	Amines
14	(1)	pH of acid rain	Environmental chemistry
15	(1)	Types and properties of adsorption	Surface chemistry
16	(2)	Properties of nitrogen containing compounds	Amines

17	(2)	Poly halogens compounds	Halo alkane and Halo arenes
18	(4)	Duma method	General organic chemistry
19	(4)	Electronic configuration	Structure of atom
20	(3)	Properties of carbonyl compounds	Aldehyde and ketones
21	[17]	First order reaction	Chemical kinetics
22	[173]	Calculation of enthalpy change	Thermodynamics
23	[59]	Percentage composition of metal ion	Solid state
24	[25]	Calculation of molar conductivity	Electro chemistry
25	[10]	Calculation of solubility product	Ionic equilibrium
26	[480]	Calculation of wavelength via CFSE	Coordination chemistry
27	[2]	Stability of superoxide	s block
28	[3]	Haloform test	Aldehyde and ketones
29	[227]	Combustion reaction	Some basic concepts of chemistry
30	[5]	Structure based questions	Chemical bonding

## Solutions

### Section A

#### 1. Option (1) is correct.

Van Arkel Method for Refining Zirconium or Titanium: This method is very useful for removing all the oxygen and nitrogen present in the form of impurity in certain metals like and Ti. The crude metal is heated in an evacuated vessel with iodine. The metal iodide being more covalent, volatilises:

The metal iodide is decomposed on a tungsten filament, electrically heated van Arkel Method for Refining Zirconium or Titanium: This method is very useful for removing all the oxygen and nitrogen present in the form of impurity in certain metals like and Ti. The crude metal is heated in an evacuated vessel with iodine. The metal iodide being more covalent, volatilises The metal iodide is decomposed on a tungsten filament, electrically heated to about The pure metal deposits on the filament.to about 1800K.

#### 2. Option (1) is correct.

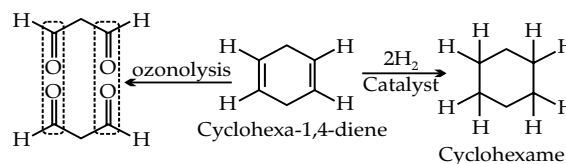
The first ionization enthalpy of 3 d-block elements is higher than the Group-II elements due to the poor shielding effect of d-orbitals.

#### 3. Option (4) is correct.

H<sub>2</sub>O<sub>2</sub> is used in the synthesis of hydroquinone, tartaric acid and certain food products and pharmaceuticals (cephalosporin).

Nowadays it is also used in environmental (green) chemistry for example in pollution control treatment of domestic and industrial effluents, oxidation of cyanides restoration of aerobic condition to sewage waste. Hence both statements are correct.

#### 4. Option (1) is correct.



Methane dicarbaldehyde

#### 5. Option (2) is correct.

A is wrong. The elevation in boiling point is different for 0.1 M NaCl and 0.1 M urea since the number of particles of solute are different in both the solutions.

B is correct. The solution that boils at constant temperature without change in composition are called the azeotropic mixtures. Hence, the statement is true.

C is wrong. In osmosis, the flow of solvent molecule is always from hypotonic to hypertonic solutions.

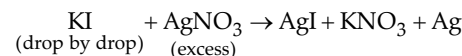
D is correct. The density and molarity of the solution is related as:

$$\text{Molarity} = \frac{\text{Mass percentage} \times \text{density} \times 10}{\text{Mol.Mass}}$$

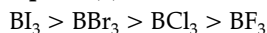
$$4.09 = \frac{32 \times \text{density} \times 10}{98}$$

$$\text{Density} = 1.26 \text{ g/mL}$$

Explanation of option (E)



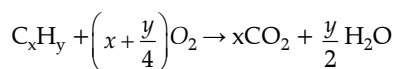
Positively charged sol is formed when KI solution is added to the silver nitrate solution. Due to adsorption of Ag<sup>+</sup> ions from dispersion medium.

**6. Option (1) is correct.**

Despite fluorine is the most electronegative element,  $BF_3$  is the weakest Lewis acid because of presence of back-bonding in between B and F due to small size. Greater is the extent of backbonding weaker is the Lewis acidic strength.

**7. Option (3) is correct.**

The combustion of hydrocarbon is:



$$\text{Equivalents of Oxygen} = \left(x + \frac{y}{4}\right) = 11$$

$$\text{Equivalents of Water} = \left(\frac{y}{2}\right) = 4$$

Solving two equations, we get  $y=8$ , and  $x=9$ . Thus, the hydrocarbon is  $C_9H_8$ .

**8. Option (1) is correct.**

The energy of orbitals =  $(n+l)$ . Higher is the value of "n", higher is the energy.

(A).  $(n+l) = (3+0)=3$ , (B).  $(n+l) = (4+0) = 4$ ,

(C).  $(n+l) = (3+1) = 4$ , (D).  $(n+l)=(3+2)=5$

Hence, the correct order is: (D)>(B)>(C)>(A)

**9. Option (4) is correct.**

Calcium plays important role in neuromuscular function, interneuronal transmission, cell membrane etc.

**10. Option (4) is correct.**

On treatment with metal salt, boric anhydride forms metaborate of the metal which gives different colours in oxidising and reducing flame.

Upon heating a borax bead dipped in cupric sulphate in a luminous flame, the colour of the bead becomes blue due to the formation of cupric metaborate  $Cu(BO_2)_2$ . In reducing flame The blue-green of is reduced to colourless cuprous metaborate. Also Cupric metaborate may be reduced to metallic copper and bead appears red opaque. Thus both the statements are incorrect.

**11. Option (1) is correct.**

Veronal is tranquilizer and prontosil is an anti-biotic drug.

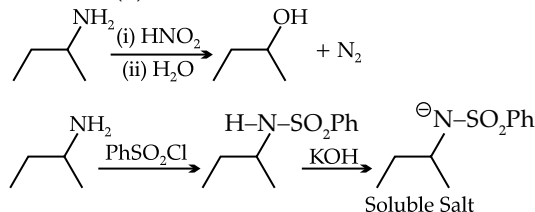
**12. Option (1) is correct.**

Methyl orange is a suitable indicator for a strong acid vs strong base titration, not for a weak acid vs weak base titration. In a weak acid vs weak base titration, the pH at the equivalence point is typically around 7, which is within the pH range where methyl orange undergoes a color change. Therefore, methyl orange is not suitable for use in weak acid vs weak base titrations. Thus statement (B) is incorrect.

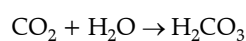
**13. Option (4) is correct.**

Only primary amines react with  $PhSO_2Cl$  to produce a compounds which are soluble in KOH.

Option (B) and (D) are primary amines but the given compound is also optically active. Hence the correct answer is (B).

**14. Option (1) is correct.**

The normal rainwater is slightly acidic because of dissolved carbon dioxide. The carbon dioxide forms carbonic acid with water which makes rainwater acidic.

**15. Option (1) is correct.**

(A) The heat of adsorption for

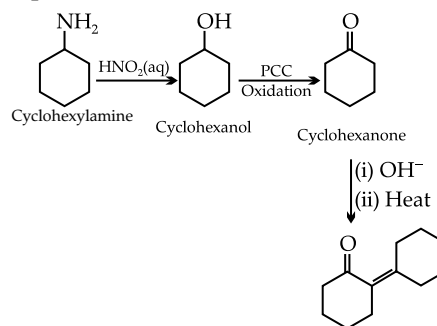
Physisorption = 20 – 40 kJ/mol and

Chemisorption = 80 – 240 kJ/mol

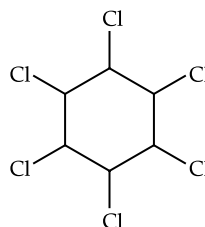
(B) Physisorption is multi-layered and chemisorption is unimolecular layered.

(C) In heterogeneous catalysis, medium and catalyst are in different phases.

(D) Chromatography uses adsorption to purify/separate mixtures.

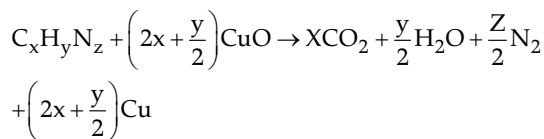
**16. Option (2) is correct.****17. Option (2) is correct.**

Gammexene has six chlorine atoms per molecule.

**18. Option (4) is correct.**

In Dumas method the organic compounds containing nitrogen produce oxides of nitrogen when heated. The oxides of nitrogen are passed through hot

copper so as to reduce all oxides of nitrogen to the nitrogen gas.

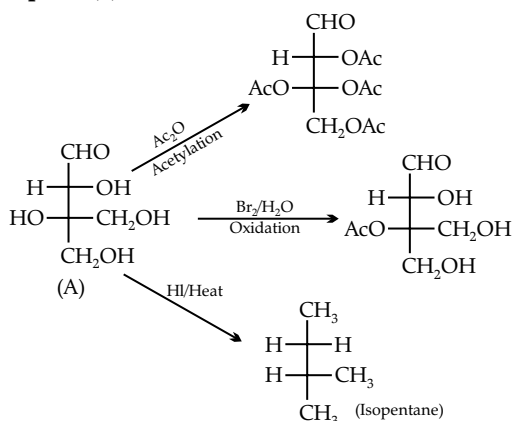


19. Option (4) is correct.

61	Pm	$4f^6 6s^2$
62	Sm	$4f^6 6s^2$
63	Eu	$4f^7 6s^2$
64	Gd	$4f^7 5d^1 6s^2$
65	Tb	$4f^9 6s^2$

Eu & Gd has half filled

20. Option (3) is correct.



### Section B

21. The correct answer is [17].

For the first order reaction,

$$K = \frac{2.303}{t} \log \frac{[R]_0}{[R]_t}$$

$$\therefore 20 = \frac{2.303}{t} \log \frac{1}{32}$$

$$\therefore t = 17 \times 10^{-2} \text{ min}^{-1}$$

22. The correct answer is [173].

$$\Delta_r H = \Delta_r H(\text{CO}_2) + 4\Delta_r H(\text{HCl}) - \Delta_r H(\text{CCl}_4) - 2\Delta_r H(\text{H}_2\text{O})$$

$$\Delta_r H = (-394) - 92 \times 4 [(-105) + (-242 \times 2)]$$

$$= (-762) - [-589] = -173 \text{ KJ/mol (nearest integer)}$$

23. The correct answer is [59].

Let the number of  $\text{M}^{2+}$  ions =  $x$

Thus, number of  $\text{M}^{3+}$  ions =  $(83-x)$ . The compound is electrically neutral. Hence,

$$2x + 3(83 - x) = 2 \times 100$$

$$\therefore x = 49$$

$$\text{Percentage of divalent ions} = \frac{40}{83} \times 100 = 59\%$$

24. The correct answer is [25].

$$\text{Conductivity (K)} = \frac{1}{\text{Resistivity}} = \frac{1}{5 \times 10^{-3} \Omega \text{ cm}}$$

$$\Lambda_m = \frac{K \times 1000}{M} = \frac{1}{5 \times 10^{-3} \Omega \text{ cm}} \times \frac{1000}{0.8 \frac{\text{mol}}{\text{cm}^2}}$$

$$= 25 \times 10^4 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$$

25. The correct answer is [10].

$$K_{sp} = (\text{Ag}^+)(\text{Cl}^-)$$

$$= s \times s$$

$$= s^2$$

$$s = \sqrt{K_{sp}}$$

$$s = 1.434 \times 10^{-3} / 143.4$$

$$= 10^{-5} \text{ mol/L}$$

$$K_{sp} = s^2 \Rightarrow (10^{-5})^2 = 10^{-10}$$

$$-\log K_{sp} = -\log 10^{-10} = 10$$

26. The correct answer is [480].

The configuration of  $\text{Ti}^{3+}$  is  $t^2 g^1 e g^0$

$$\text{CFSE} = (-0.4x + 0.6y) \Delta_0$$

$$-96 = (-0.4(1) + 0.6(0)) \Delta_0$$

$$\Delta_0 = 240 \text{ kJ mol}^{-1} = \frac{hc}{\lambda}$$

$$\frac{240}{6 \times 10^{23}} = \frac{6.4 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\lambda = 480 \text{ nm}$$

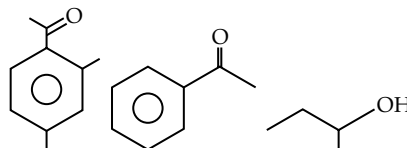
27. The correct answer is [2].

Elements	Li	K	Rb	Cs
Ionisation enthalpy KJ/mol	520	419	403	376

Li does not form superhydride, K, Rb and Cs form stable super oxide but Cs has ionisation enthalpy less than look j/mol K and Rb have ionisation enthalpy greater than 400 K J/mol

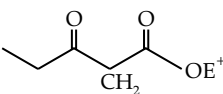
28. The correct answer is [3].

The compounds with methyl ketone group  $\text{CH}_3\text{C}(=\text{O})$  or secondary alcohol group  $\text{CH}_3\text{CH}(\text{OH})$  gives the iodoform test positive.



(This compound although contains  $\text{CH}_3\text{C}(=\text{O})$  will not

show iodoform test because of methyl group present at ortho position which causes hindrance).

Also  will show the +ve iodoform test although it does not contain  $\text{CH}_3\text{C}(=\text{O})$ .

This is because it contains active methylene group. Thus total 3 compounds give +ve iodoform test.

**29. The correct answer is [227].**

As per the reaction, the moles of CO formed is equal to the moles of carbon consumed.

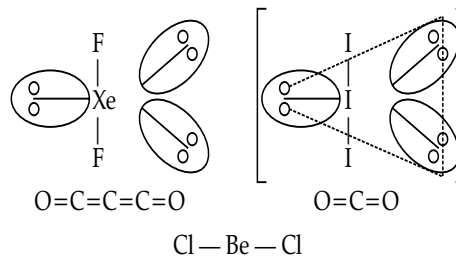
Moles of carbon consumed = Moles of CO formed

$$\therefore \frac{12}{12} = \frac{\text{Volume of CO}}{22.7\text{L}}$$

$$\text{Volume of CO} = 227 \times 10^{-1} \text{ L}$$

**30. The correct answer is [5].**

$\text{XeF}_2$ ,  $\text{I}_3^-$ ,  $\text{C}_3\text{O}_2$ ,  $\text{CO}_2$  and  $\text{BeCl}_2$  have the linear shape.



□□