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**INDIAN ASSOCIATION OF PHYSICS TEACHERS**  
**NATIONAL STANDARD EXAMINATION IN CHEMISTRY - 2022**

**Date of Examination: November 27, 2022**

**Time: 11:30 AM to 1:30 PM**

**Question Paper Code: 31**

|                       |  |  |  |  |  |  |  |  |  |
|-----------------------|--|--|--|--|--|--|--|--|--|
| Student's<br>Roll No: |  |  |  |  |  |  |  |  |  |
|-----------------------|--|--|--|--|--|--|--|--|--|

*Write the question paper code (mentioned above) on YOUR OMR Answer Sheet (in the space provided), otherwise your Answer Sheet will NOT be evaluated. Note that the same Question Paper Code appears on each page of the question paper.*

**Instructions to Candidates:**

1. Use of mobile phone, smart watch, and ipad during examination is STRICTLY PROHIBITED.
2. In addition to this question paper, you are given OMR Answer Sheet along with Candidate's copy.
3. On the OMR sheet, make all the entries carefully in the space provided **ONLY** in **BLOCK CAPITALS** as well as by properly darkening the appropriate bubbles.

**Incomplete/ incorrect/ carelessly filled information may disqualify your candidature.**

4. On the OMR Answer Sheet, use only **BLUE** or **BLACK BALL POINT PEN** for making entries and filling the bubbles.
5. Your **Ten-digit roll number and date of birth** entered on the OMR Answer Sheet shall remain your login credentials means login id and password respectively for accessing your performance / result in NSEC - 2022.
6. Question paper has two parts. In part A1 (Q. No.1 to 48) each question has four alternatives, out of which **only one** is correct. Choose the correct alternative and fill the appropriate bubble, as shown.

**Q.No. 12**   ☐ a   ☒   ☐ c   ☐ d

In part A2 (Q. No. 49 to 60) each question has four alternatives out of which any number of alternative (s) (1, 2, 3, or 4) may be correct. You have to choose all correct alternative(s) and fill the appropriate bubble(s), as shown

**Q.No. 52**   ☐ a   ☒   ☐ c   ☒

7. For **Part A1**, each correct answer carries 3 marks whereas 1 mark will be deducted for each wrong answer. In **Part A2**, you get 6 marks if all the correct alternatives are marked. No negative marks in this part.
8. Rough work may be done in the space provided. There are 16 printed pages in this paper
9. Use of **non - programmable scientific** calculator is allowed.
10. No candidate should leave the examination hall before the completion of the examination.
11. After submitting answer paper, take away the question paper & Candidate's copy OMR sheet for your reference.

**Please DO NOT make any mark other than filling the appropriate bubbles properly in the space provided on the OMR answer sheet.**

**OMR answer sheets are evaluated using machine, hence CHANGE OF ENTRY IS NOT ALLOWED. Scratching or overwriting may result in a wrong score.**

**DO NOT WRITE ON THE BACK SIDE OF THE OMR ANSWER SHEET.**

**Instructions to Candidates (Continued) :**

*You may read the following instructions after submitting the answer sheet.*

12. **Comments/Inquiries/Grievances regarding this question paper, if any, can be shared on the Inquiry/Grievance column on [www.iapt.org.in](http://www.iapt.org.in) on the specified format till December 3, 2022**
13. **The answers/solutions to this question paper will be available on the website: [www.iapt.org.in](http://www.iapt.org.in) by December 2, 2022.**
14. **CERTIFICATES and AWARDS:**  
 Following certificates shall be awarded by IAPT/ACT to the students, successful in the NATIONAL STANDARD EXAMINATION IN CHEMISTRY – 2022
  - (i) CENTRE TOP 10 % To be downloaded from [iapt.org.in](http://iapt.org.in) after 15.01.23
  - (ii) STATE TOP 1 % Will be dispatched to the examinee
  - (iii) NATIONAL TOP 1 % Will be dispatched to the examinee
  - (iv) GOLD MEDAL & MERIT CERTIFICATE to all students who attend OCSC – 2023 at HBCSE Mumbai
 Certificate for centre toppers shall be uploaded on [iapt.org.in](http://iapt.org.in)
15. List of students (with centre number and roll number only) having score above MAS will be displayed on the website: [www.iapt.org.in](http://www.iapt.org.in) by **December 25, 2022**. See the **Minimum Admissible Score** clause on the Student's brochure on the web.
16. List of students eligible to appear for Indian National Chemistry Olympiad (INChO – 2023) shall be displayed on [www.iapt.org.in](http://www.iapt.org.in) by December 30, 2022.

**Constants you may need....**

|                     |  |                     |  |
|---------------------|--|---------------------|--|
| Charge of electron, | $e = 1.602 \times 10^{-19} \text{ C}$  | Speed of light,     | $c = 3.0 \times 10^8 \text{ ms}^{-1}$  |
| Mass of electron,   | $m_e = 9.1 \times 10^{-31} \text{ kg}$ | Avogadro constant,  | $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$  |
| Planck's constant,  | $h = 6.63 \times 10^{-34} \text{ Js}$  | Faraday             | $F = 96500 \text{ C mol}^{-1}$   |
|                     |  | Molar gas constant, | $R = 0.082 \text{ L atm mol}^{-1} \text{ K}^{-1}$<br>$= 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ |

**INDIAN ASSOCIATION OF PHYSICS TEACHERS  
NATIONAL STANDARD EXAMINATION IN CHEMISTRY  
(NSEC - 2022)**

Time: 120 minute

Max. Marks: 216

Attempt All Sixty Questions

A - 1

ONLY ONE OUT OF FOUR OPTIONS IS CORRECT. BUBBLE THE CORRECT OPTION.

- The results obtained by four students, each performing a set of four titrations with the same solution under identical conditions, are given below. If the expected titre value is 20.0 mL, the set of data (mL) with good accuracy and poor precision is  
 (a) 19.9, 20.0, 20.1, 19.9 (b) 18.1, 18.2, 18.0, 18.1  
 (c) 17.9, 18.1, 21.5, 21.0 (d) 20.0, 19.8, 19.4, 20.2
- The statement that is NOT correct about atomic spectra is  
 (a) Electric discharges through gases produce line spectra  
 (b) Each element in the gaseous state has a unique line spectrum  
 (c) The number of lines in the spectrum is same as the number of electrons in the atom  
 (d) Atoms can emit photons with wavelengths lower than that of visible light
- A closed 2.0 L container initially holds 3.0 mol of  $O_2$  (g) and 2.0 mol of  $N_2$  (g) at room temperature, T. If the pressure remains constant when 1.0 mol of  $O_2$  (g) is added, the final temperature of the system is- (Assume ideal gas behaviour throughout)  
 (a)  $(3/5)T$  (b)  $(5/6)T$  (c)  $2T$  (d)  $(6/5)T$
- The equilibrium constant ( $K_c$ ) for trimerization of phenyl acetylene to triphenyl benzene is 3.0 at 310 K. If at equilibrium,  $0.9 \text{ mol dm}^{-3}$  of triphenyl benzene is present, concentration of phenyl acetylene at equilibrium is:  
 (a)  $1/3 \text{ mol dm}^{-3}$  (b)  $3.0 \text{ mol dm}^{-3}$  (c)  $1.732 \text{ mol dm}^{-3}$  (d)  $0.67 \text{ mol dm}^{-3}$
- At 298 K, the standard free energies of formation of *cis*- and *trans*-1,2-dichloroethene are 41.549 kJ and 33.235 kJ respectively. The most appropriate mol ratio of *trans*- and *cis*- isomers at equilibrium at 298 K is  
 (a) 10:3 (b) 3:10 (c) 28:1 (d) 1:28
- The pH of the solution produced by complete consumption of 10 mL of 0.4 M NaOH to 'x' mL of 0.5M  $CH_3COOH$  was found to be 4.57. The value of 'x' (mL) is (Given- $K_a$  of  $CH_3COOH = 1.8 \times 10^{-5}$ ).  
 (a) 12.0 (b) 10.4 (c) 19.8 (d) 6.5
- The correct order of concentrations of the ions/molecules present in 1.0 L of 1.0 M  $H_2SO_4$  (aq) solution is  
 (a)  $OH^- < SO_4^{2-} < HSO_4^- < H_3O^+ < H_2O$  (b)  $OH^- < HSO_4^- < SO_4^{2-} < H_3O^+ < H_2O$   
 (c)  $H_2O < HSO_4^- < OH^- < SO_4^{2-} < H_3O^+$  (d)  $H_2O < OH^- < SO_4^{2-} < HSO_4^- < H_3O^+$

8. The pOH of the solution obtained by mixing 30 mL of a strong monobasic acid of pH 3.0 and 70 mL of a strong monoacidic base of pH 12.0 at 298 K is  
 (a) 3.17 (b) 2.17 (c) 5.17 (d) 0.17
9. If refractive index, density, pressure, volume, heat capacity and surface tension are represented respectively as  $\eta$ ,  $\rho$ ,  $P$ ,  $V$ ,  $Q$  and  $\gamma$ , the set that contains only intensive properties is  
 (a)  $\eta$ ,  $\rho$ ,  $\gamma$ ,  $Q$  (b)  $\rho$ ,  $P$ ,  $Q$ ,  $\gamma$  (c)  $V$ ,  $Q$ ,  $\eta$ ,  $\rho$  (d)  $\eta$ ,  $\rho$ ,  $P$ ,  $\gamma$
10. Heat of reaction and heat of formation will be the same in  
 I.  $\frac{1}{2} \text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}_2(\text{g})$   
 II.  $\text{Xe}(\text{g}) + 2\text{F}_2(\text{g}) \rightarrow \text{XeF}_4(\text{g})$   
 III.  $\text{N}_2(\text{g}) + \text{O}_3(\text{g}) \rightarrow \text{N}_2\text{O}_3(\text{g})$   
 IV.  $\text{C}(\text{diamond}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$   
 (a) Only I (b) Only I and II (c) Only I, II and III (d) Only II, III and IV
11. From the following data  
 $2\text{CH}_6\text{N}_2(\ell) + 5\text{O}_2(\text{g}) \rightarrow 2\text{N}_2(\text{g}) + 2\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$  ( $\Delta H_r^\circ = -2606 \text{ kJ}$ ) and  
 $\text{H}_2\text{O}(\ell) \rightarrow \text{H}_2\text{O}(\text{g})$  ( $\Delta H_v^\circ = 44 \text{ kJ mol}^{-1}$ )  
 Heat of combustion of  $\text{CH}_6\text{N}_2$  at 298K can be calculated as  
 (a)  $-1567 \text{ kJ mol}^{-1}$  (b)  $-1435 \text{ kJ mol}^{-1}$  (c)  $-1171 \text{ kJ mol}^{-1}$  (d)  $-2342 \text{ kJ mol}^{-1}$
12. When 100 g each of the salts  $\text{NaCl}$ ,  $\text{MgSO}_4$ ,  $\text{Ca}(\text{NO}_3)_2$ ,  $\text{K}_2\text{CO}_3$ , were dissolved separately in 1.0 kg of water, the solution with the highest boiling point will be of  
 (a)  $\text{Ca}(\text{NO}_3)_2$  (b)  $\text{MgSO}_4$  (c)  $\text{NaCl}$  (d)  $\text{K}_2\text{CO}_3$
13. When the pH of the system is increased by 2.0 units, maximum decrease in half cell potential for the reaction will be observed in  
 (a)  $\text{V}^{2+}(\text{aq}) \rightarrow \text{V}^{3+}(\text{aq}) + \text{e}^-$  (b)  $\text{VO}_3^- + 2\text{H}^+ \rightarrow \text{VO}_2^+ + \text{H}_2\text{O}$   
 (c)  $\text{VO}^{2+} + 2\text{H}^+ + \text{e}^- \rightarrow \text{V}^{3+} + \text{H}_2\text{O}$  (d)  $\text{VO}^{2+} + \text{H}_2\text{O} \rightarrow \text{VO}_2^+ + 2\text{H}^+ + \text{e}^-$
14. The reaction that takes place during charging of the lead storage cell is given below  
 $2\text{PbSO}_4(\text{s}) + 2\text{H}_2\text{O}(\ell) \rightarrow \text{Pb}(\text{s}) + \text{PbO}(\text{s}) + 2\text{H}_2\text{SO}_4(\text{aq})$   
 If a current of 10.0 A is passed for 1.50 h for charging, the amount of  $\text{PbSO}_4$  reacted is  
 (a) 25.0 g (b) 56.0 g (c) 120.5 g (d) 170.0 g
15. A sample of water from a water tank has a resistance of  $100 \Omega$  at 298 K, when placed in a conductivity cell of cell constant  $0.2 \text{ m}^{-1}$ . On dissolving 58.5 g of  $\text{NaCl}$  in the water tank, a sample of this solution gave a resistance of  $40 \Omega$ . The molar conductivity of  $\text{NaCl}$  at this concentration is  $10 \Omega^{-1} \text{ m}^2 \text{ mol}^{-1}$ . The volume of water in the water tank is  
 (a)  $3.33 \times 10^6 \text{ L}$  (b) 3333.3 L (c) 363.5 L (d)  $4.2 \times 10^5 \text{ L}$

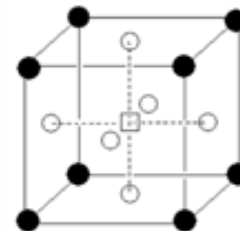


16. Initial concentrations of the reactants and the corresponding half-lives for the reaction  $P + Q \rightarrow R$  are given below. The rate law for the reaction is

| Entry | $[P_0]$ (mol dm <sup>-3</sup> x 10 <sup>-6</sup> ) | $[Q_0]$ (mol dm <sup>-3</sup> x 10 <sup>-6</sup> ) | $t_{1/2}$ (s) |
|-------|--|--|---------------|
| 1     | 500  | 10   | 30            |
| 2     | 500  | 20   | 60            |
| 3     | 10   | 500  | 60            |
| 4     | 20   | 500  | 60            |

- (a)  $dR/dt = k[P]$       (b)  $dR/dt = k[P]/[Q]$       (c)  $dR/dt = k[Q]$       (d)  $-d[P]/dt = k[P]/[Q]$

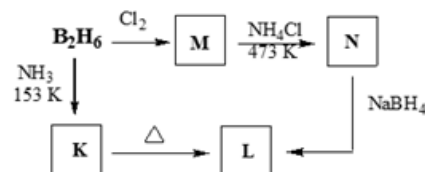
17. The unit cell structure of a mineral perovskite crystallizes in cubic unit cell wherein calcium (filled circles) and oxide (hollow circles) constitute a cubic close packing (ccp) arrangement and titanium ion (hollow square) occupies an interstitial hole as shown below. (Charges are omitted for simplicity). The empirical formula of this compound is



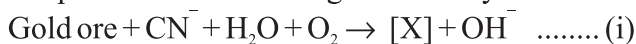
- (a)  $Ca_2TiO_3$       (b)  $Ca_4TiO_6$   
(c)  $CaTiO_3$       (d)  $Ca_8TiO_6$

18. Study the sequence of reactions of diborane ( $B_2H_6$ ) given below and identify the products K, L, M and N. (The shown reagents are taken in excess).

- (a)  $K = BNH_6$ ;  $L = (BN)_x$ ;  $M = B_2H_5Cl$ ;  $N = B_3N_3H_3Cl_3$   
(b)  $K = [B_2H_6 \cdot 2NH_3]$ ;  $L = B_3N_3H_6$ ;  $M = B_2H_5Cl$ ;  $N = B_3N_3Cl_6$   
(c)  $K = BNH_6$ ;  $L = (BN)_x$ ;  $M = BCl_3$ ;  $N = B_3N_3Cl_6$   
(d)  $K = [B_2H_6 \cdot 2NH_3]$ ;  $L = B_3N_3H_6$ ;  $M = BCl_3$ ;  $N = B_3N_3H_3Cl_3$



19. During extraction of gold, the gold ore is treated with aqueous KCN solution as shown by the equations (not balanced) below to get compound X which is further reduced by Zn to obtain compound Y and metallic gold. Identify X and Y.



- (a)  $X = [Au(CN)_2]^-$ ,  $Y = [Zn(CN)_2]^{2-}$       (b)  $X = [Au(CN)_2]^-$ ,  $Y = [Zn(CN)_4]^{2-}$   
(c)  $X = [Au(CN)_4]^{3-}$ ,  $Y = [Zn(CN)_4]^{2-}$       (d)  $X = [Au(CN)_2]^-$ ,  $Y = [Zn(CN)_4]^{4-}$

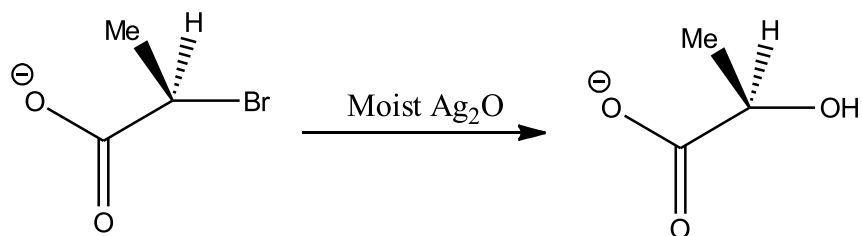
20. The correct IUPAC name for the complex  $[Au(en)_2(H_2O)_2][Au(ox)_3]$  is (en=ethylenediamine and ox=oxalate)

- (a) Bisaquobisethylenediaminegold (III) trioxalatoaurate (III)  
(b) Diaquobisethylenediamineaurate (III) trisoxalatogold (III)  
(c) Bisquodiethylenediamineaurate (III) trisoxalatogold (III)  
(d) Diaquobisethylenediaminegold (III) trioxalatoaurate (III)

21. Addition of dil. HCl to an aqueous solution of a mixture of two inorganic salts yielded white precipitate **E** and filtrate **F**. Precipitate **E** dissolved in hot water. **F** in alkaline alizarin gives a positive red lake test. The cations present in the precipitate **E** and solution **F** respectively are  
 (a)  $\text{Ag}^+; \text{Fe}^{3+}$  (b)  $\text{Hg}^{2+}; \text{Ba}^{2+}$  (c)  $\text{Pb}^{2+}; \text{Al}^{3+}$  (d)  $\text{Pb}^{2+}; \text{Zn}^{2+}$
22.  $\text{Br}_2$  disproportionates to  $\text{Br}^-$  and  $\text{BrO}_3^-$  in a hot alkaline solution as  

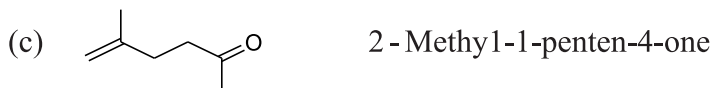
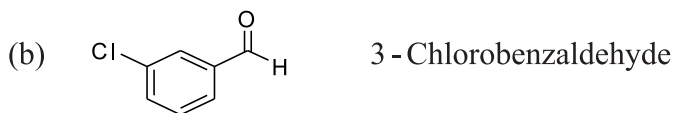
$$3\text{Br}_2 + 6\text{OH}^- \rightarrow 5\text{Br}^- + \text{BrO}_3^- + 3\text{H}_2\text{O}$$
  
 The equivalent weight of  $\text{Br}_2$  is: ( $M$  = molar mass of  $\text{Br}_2$ )  
 (a)  $M/5$  (b)  $M/6$  (c)  $3M/5$  (d)  $5M/3$
23. The number of all the possible geometrical isomers for trigonal bipyramidal  $\text{OsO}_2\text{F}_3^+$  cation is:  
 (a) 2 (b) 3 (c) 1 (d) 4
24. The correct order for the wavelength of absorption in the following complex ions is  
 (a)  $[\text{Ni}(\text{NO}_2)_6]^{4-} < [\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{H}_2\text{O})_6]^{2+}$   
 (b)  $[\text{Ni}(\text{NO}_2)_6]^{4-} < [\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NH}_3)_6]^{2+}$   
 (c)  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{NO}_2)_6]^{4-}$   
 (d)  $[\text{Ni}(\text{NH}_3)_6]^{2+} < [\text{Ni}(\text{H}_2\text{O})_6]^{2+} < [\text{Ni}(\text{NO}_2)_6]^{4-}$
25. Mixing of an aqueous salt solution containing nitrate ion with ferrous ion followed by gentle addition of conc. sulphuric acid from the sides of the test tube, results in brown coloration at the interface is due to  
 (a) interaction of ferrous ion with nitric oxide  
 (b) interaction between the resulting nascent oxygen, ferrous ion and nitrate ion  
 (c) formation of ferrous ion and nitrogen dioxide  
 (d) complex formation between ferrous ion and nitrate ion
26. Aqueous solutions of hydrogen sulphide and sulphur dioxide when mixed together gives  
 (a) bisulphite ion and water (b) hydrogen and sulphurous acid  
 (c) sulphur and water (d) hydrogen peroxide and sulphur
27. The ion with least coagulation value for arsenous sulphide sol is  
 (a)  $\text{SO}_4^{2-}$  (b)  $\text{PO}_4^{3-}$  (c)  $\text{Al}^{3+}$  (d)  $\text{Ba}^{2+}$
28. The correct order of catenation property among the following is  
 (a)  $\text{Pb} > \text{Si} > \text{Ge} > \text{Sn}$  (b)  $\text{Pb} > \text{Sn} > \text{Ge} > \text{Si}$   
 (c)  $\text{Si} > \text{Sn} > \text{Ge} > \text{Pb}$  (d)  $\text{Si} > \text{Ge} > \text{Sn} > \text{Pb}$
29. An agriculturist wants to use different concentrations of phosphorus as a fertilizer using  $\text{P}_4\text{O}_{10}$ . The correct expression to calculate P from  $\text{P}_4\text{O}_{10}$  is  
 (a)  $\text{P}_4\text{O}_{10} \times 2.29$  (b)  $\text{P} \times 0.44$  (c)  $\text{P} \times 2.29$  (d)  $\text{P}_4\text{O}_{10} \times 0.44$

30. Given below are some names of the compounds.  
 (p) Acetals; (q) silicones; (r) ferrocene; (s) glyoxal, (t) ethyl acetate, (u) gammaxene  
 The set which is **NOT** having a double bond between an element and O(E=O where E is any element in the periodic table) as a functional group is  
 (a) p, s, u, t (b) p, q, r, s (c) q, r, s, t (d) p, q, r, u
31. Hybridization of S in  $\text{CH}_3\text{SH}$  molecule is  
 (a)  $\text{dsp}^3$  (b)  $\text{sp}^2$  (c)  $\text{sp}^3$  (d)  $\text{sp}^3\text{d}$
32. Using different reaction conditions nickel reacts with (p)  $\text{Cl}^-$ , (q)  $\text{CN}^-$ , (r) CO and (s) small amount of Al. Choose **incorrect** statement.  
 (a) (p), (q), and (r) respectively can result in tetrahedral, octahedral and square planar geometries around nickel  
 (b) Ligand (p) and (q) leads to homoleptic complex formation wherein final electronic configuration shows maximum multiplicity in case of (p)  
 (c) Ligand (r) reacts only in reducing medium to form organometallic compound  
 (d) In case of (s) formation of spongy product with large surface drive reduction reaction of  $\text{C}=\text{C}$  compounds
33. Optically pure 2-butanol has a specific rotation of  $+13.52$  degrees. A synthesized and purified sample of 2-butanol has the observed specific rotation of  $+6.76$  degrees. The correct statement based on this observation is  
 (a) the sample is completely racemized (b) 25% of the sample is racemic  
 (c) 50% of the sample is racemic (d) 6.76% of the sample is racemic
34. Certain organic reactions proceed through formation of intermediates which are highly strained and reactive. Given the following reaction, the correct statement about the mechanism of the reaction is

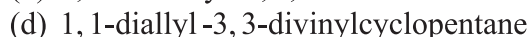
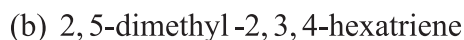


- (a) Intramolecular  $\text{S}_{\text{N}}2$  attack by  $-\text{COO}^-$  to form an intermediate followed by the attack by  $\text{HO}^-$  via  $\text{S}_{\text{N}}2$  pathway on the intermediate  
 (b) Intramolecular  $\text{S}_{\text{N}}2$  attack by  $-\text{COO}^-$  to form an intermediate followed by the attack by  $\text{HO}^-$  via  $\text{S}_{\text{N}}1$  pathway on the intermediate  
 (c)  $\text{HO}^-$  attacks via  $\text{S}_{\text{N}}1$  pathway on the reactant  
 (d)  $\text{HO}^-$  attacks via  $\text{S}_{\text{N}}2$  pathway on the reactant

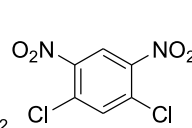
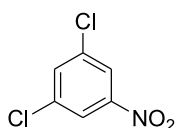
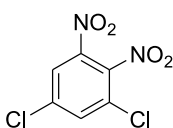
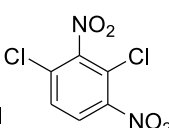
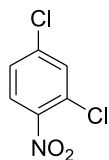
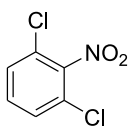
35. Which of the following compound is **NOT** named correctly according to the IUPAC nomenclature?



36. Which of the following compounds contains the maximum number of  $sp^2$  hybridized carbon atoms?



37. The number of products from the following, which cannot be formed on nitration of 1,3-dichlorobenzene with a mixture of concentrated nitric acid and sulfuric acid is



(i)

(ii)

(iii)

(iv)

(v)

(vi)

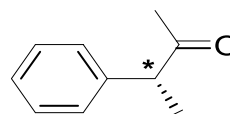
(a) Four

(b) Three

(c) Two

(d) One

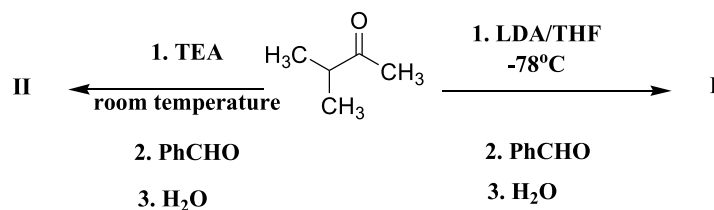
38. Optically pure 3-Phenyl-2-butanone (X) with the following structure is treated with methyl magnesium iodide in anhydrous ether. The product formed after acidic hydrolysis is

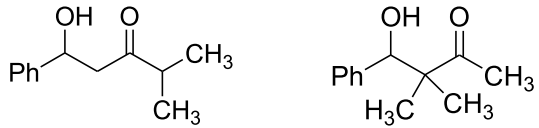
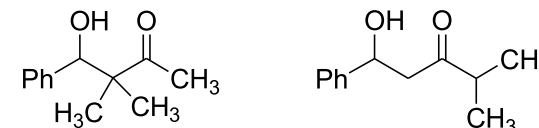
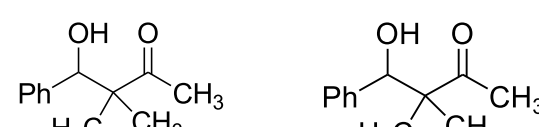
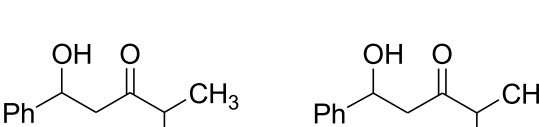


[X]

3-phenyl-2-butanone

39. Aldehydes react with carbonyl compounds in the presence of bases by a mechanism similar to aldol condensation. Given below is the reaction of benzaldehyde with 3-methyl-2-butanone in the presence of lithium diisopropylamide (LDA), a strong bulky base and triethyl amine (TEA), a weak base. The correct structures of the major products, **I** and **II** formed in the following reactions are respectively



- I**
**II**
- (a) 
- (b) 
- (c) 
- (d) 

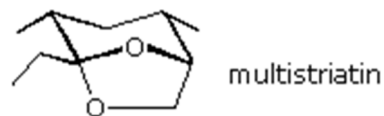
40. The correct order of the given reagents to convert benzene to m-Chlorobromobenzene is

|                                    |  |   |   |  |
|------------------------------------|--|---|---|--|
| (1) sulfuric acid (conc.) and heat | (2) $\text{Cl}_2 + \text{FeCl}_3$ and heat | (3) $\text{NaNO}_2 + \text{H}_3\text{O}^+$ $0^\circ\text{C}$          | (4) $\text{H}_2$ Pt catalyst              | (5) Mg in ether                                    |
| (6) $\text{PBr}_3$                 | (7) $\text{H}_3\text{PO}_2$ (aqueous)      | (8) $\text{HNO}_3$ (conc.) + $\text{H}_2\text{SO}_4$ (conc.) and heat | (9) $\text{Cu}_2\text{Br}_2 + \text{HBr}$ | (10) $(\text{CH}_3\text{CO})_2\text{O}$ + pyridine |

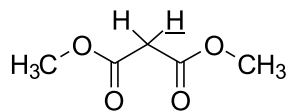
- (a) 1, 2, 5, 7 and 6      (b) 2, 8, 4, 3 and 9      (c) 8, 4, 10, 2, 3 and 9      (d) 8, 2, 4, 3 and 9

41. A chiral hydrocarbon (Molecular Formula  $C_6H_{12}$ ) undergoes catalytic hydrogenation to yield an achiral product (Molecular Formula  $C_6H_{14}$ ). The chiral hydrocarbon is  
 (a) *cis*-2-hexene (b) 3-methyl-2-pentene  
 (c) 4-methyl-2-pentene (d) 3-methyl-1-pentene

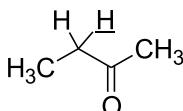
42. The structure of multistriatin, a pheromone of the elm bark beetle, is shown beside. The open chain ketodiols that on dehydrative cyclization gives multistriatin, bicyclic ketal (ignore stereo chemical aspects) is



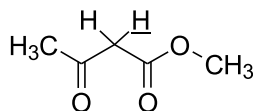
43. A monobasic acid (0.100 g) on complete combustion gave 0.252 g of  $CO_2$  and 0.044 g of  $H_2O$ . For complete neutralization of 0.122 g of the acid, 10.0 mL of 0.1M NaOH solution was required. Molecular formula of the acid is  
 (a)  $C_7H_6O_2$  (b)  $C_6H_7O_2$  (c)  $C_7H_7O_2$  (d)  $C_6H_6O_2$
44. Acidity of acidic compounds depend on the stability of their conjugate bases. The correct order of acidity of the underlined H in the following compounds is  
 (Note: Assume that all the compounds exist in the keto form)



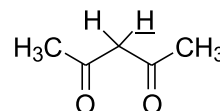
(i)



(ii)



(iii)



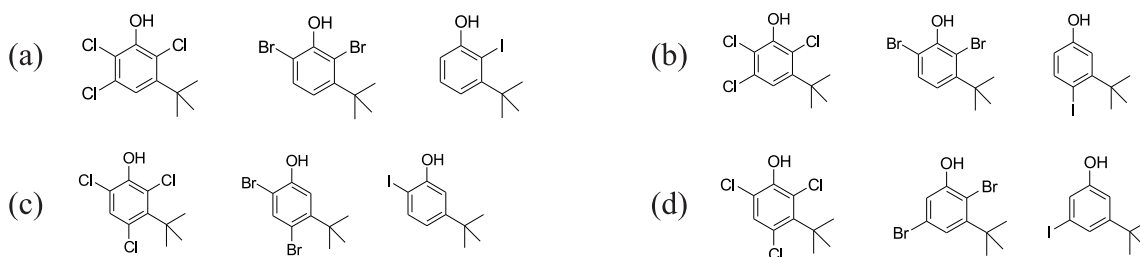
(iv)

- (a) (ii) > (iii) > (iv) > (i) (b) (iv) > (iii) > (i) > (ii)  
 (c) (iii) > (ii) > (iv) > (i) (d) (i) > (iii) > (iv) > (ii)

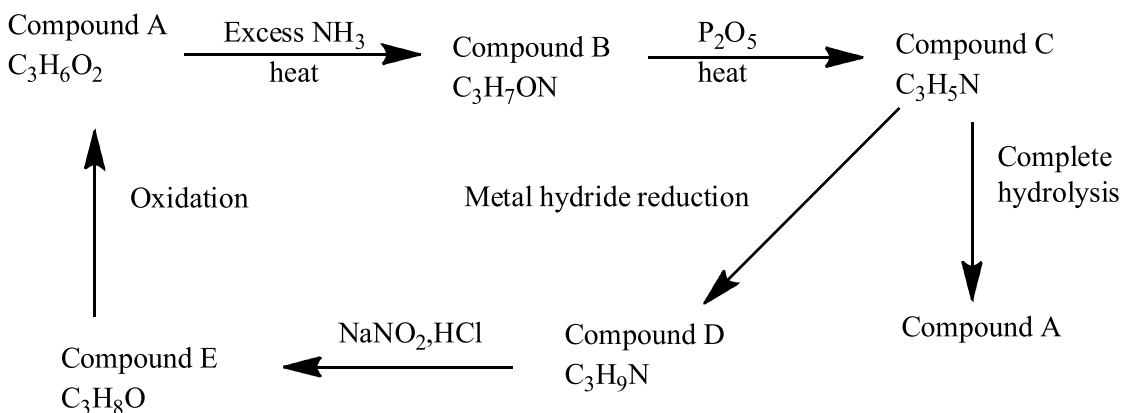
45. Reaction of *para*-Chloroaniline with acetic anhydride in pyridine gave a crude mixture of 94% of *para*-chloroacetanilide and 6% unreacted amine. From the following, the best treatment suitable for purification of *para*-chloroacetanilide is  
 (a) treating the reaction mixture with methyl iodide  
 (b) washing an ether solution of the crude product with concentrated brine (aq. NaCl)  
 (c) washing an ether solution of the crude product with 5% cold aqueous sulfuric acid  
 (d) washing an ether solution of the crude product with 5% aqueous sodium carbonate



46. 3-tert-butylphenol when reacted separately with excess chlorine, bromine and iodine gave trichloro, di-bromo and mono-iodo derivatives of 3-tert-butylphenol respectively. The correct structures of the respective halogen derivatives are



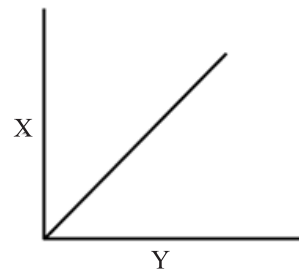
47. Consider the following sequence of reactions:  
The functional groups undergoing change in the conversion of A to E respectively are



- (a) -COOH, -NC, -CONH<sub>2</sub>, -NH<sub>2</sub>, -CH<sub>2</sub>OH  
 (b) -COOH, -CN, -CONH<sub>2</sub>, -NH<sub>2</sub>, -CH<sub>2</sub>OH  
 (c) -COOH, -CONH<sub>2</sub>, -CN, -CH<sub>2</sub>NH<sub>2</sub>, -CH<sub>2</sub>OH  
 (d) -CONH<sub>2</sub>, -COOR, -NC, -NHR, >CHOH
48. The correct sequence of reagents which would convert p-Nitrotoluene to p-Iodobenzoic acid is
- (a) (i) Br<sub>2</sub> + FeBr<sub>2</sub>, (ii) Mg in ether, then CO<sub>2</sub>, (iii) 3 H<sub>2</sub> and Pt or Ni catalyst, (iv) HNO<sub>2</sub>, 0°C, (v) KI solution  
 (b) (i) Br<sub>2</sub> in CCl<sub>4</sub> and heat, (ii) NaI in acetone, (iii) 3 H<sub>2</sub> and Pt or Ni catalyst, (iv) HNO<sub>2</sub>, 0°C, (v) H<sub>3</sub>PO<sub>2</sub>  
 (c) (i) 3 H<sub>2</sub> and Pt or Ni catalyst, (ii) HNO<sub>2</sub>, 0°C, (iii) Cu<sub>2</sub>Br<sub>2</sub> + HBr, (iv) KMnO<sub>4</sub> and heat, (v) KI solution  
 (d) (i) KMnO<sub>4</sub> and heat, (ii) 3 H<sub>2</sub> and Pt or Ni catalyst, (iii) HNO<sub>2</sub>, 0°C, (iv) KI solution

ANY NUMBER OF OPTIONS 4, 3, 2 or 1 MAY BE CORRECT  
MARKS WILL BE AWARDED ONLY IF ALL THE CORRECT OPTIONS ARE BUBBLED.

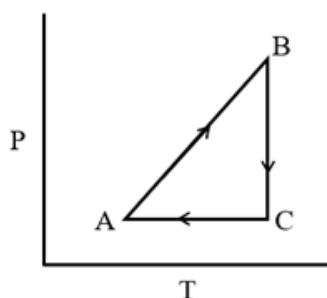
49. Following is a qualitative plot that can represent kinetic data obtained with a reactant R where  $[R]_0$  and  $[R]$  represent the concentrations of R, at  $t = 0$  and  $t = t$  respectively. 'Y' and 'X' are suitable parameters on the x- and y- axes.



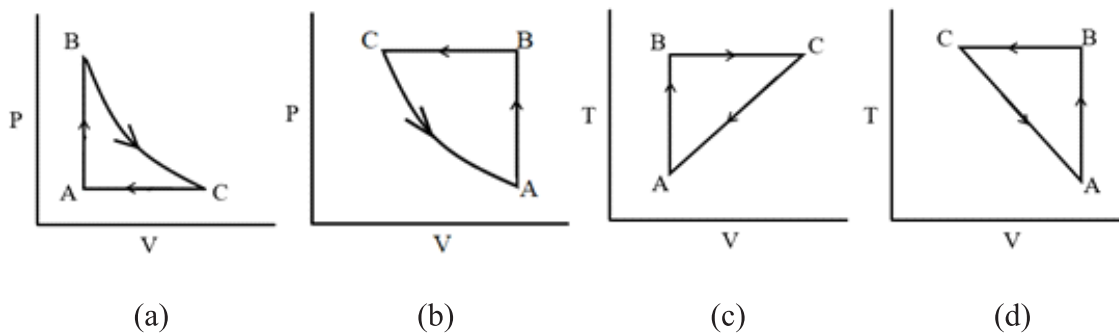
The correct representation of the curve is

|     | X             | Y       | order | X                   | Y       | order |
|-----|---------------|---------|-------|---------------------|---------|-------|
| (a) | $[R]_0 - [R]$ | time    | Zero  | Rate                | time    | First |
| (b) | $[R]_0 - [R]$ | time    | Zero  | Initial rate        | $[R]_0$ | First |
| (c) | Rate          | $[R]$   | Zero  | $t_{1/2}$           | $[R]$   | First |
| (d) | $t_{1/2}$     | $[R]_0$ | Zero  | $\ln \{[R]_0/[R]\}$ | t       | First |

50. A given amount of an ideal gas undergoes the cyclic process ABCA as given below.



The equivalent representation/s of the same process is/are

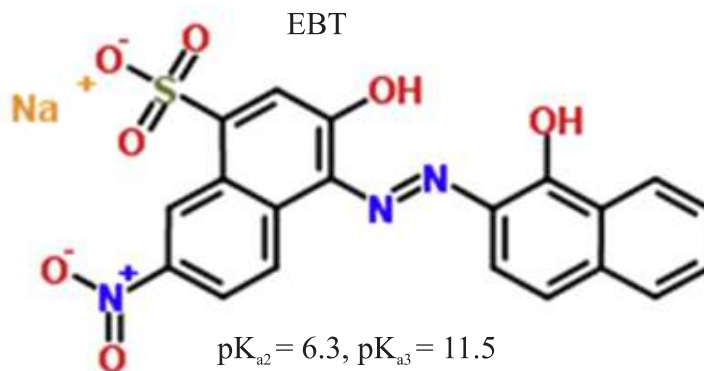


51. The correct statements among the following is /are
- When equal volumes of a solution containing  $\text{Sr}^{2+}$  (0.01M) and another containing  $\text{F}^-$  (0.001M) are mixed at  $25^\circ\text{C}$ ,  $\text{SrF}_2$  will be precipitated ( $K_{\text{sp}}$  of  $\text{SrF}_2 = 8.0 \times 10^{-10}$  at  $25^\circ\text{C}$ )
  - When equal volumes of a solution containing  $\text{Ba}^{2+}$  ( $1.0 \times 10^{-4}$  M) and another containing  $\text{F}^-$  ( $1.0 \times 10^{-2}$  M) are mixed at  $25^\circ\text{C}$ ,  $\text{BaF}_2$  will be precipitated ( $K_{\text{sp}}$  of  $\text{BaF}_2 = 1.0 \times 10^{-6}$  at  $25^\circ\text{C}$ )
  - The solubility product ( $K_{\text{sp}}$ ) and the molar solubility ( $s$ ) of  $\text{La}(\text{IO}_3)_3$  are related as  $K_{\text{sp}} = 27s^4$
  - The solubility product and the molar solubility of  $\text{Ca}_3(\text{PO}_4)_2$  are related as  $27s^4$
52. For the phenomenon of adsorption, the correct statement/s among the following is /are
- According to Freundlich model, mass of  $\text{N}_2$  gas adsorbed per g of silica surface will increase with temperature of adsorption
  - If  $S$  is the surface area of an adsorbent, and ' $A$ ', ' $m$ ' and ' $M$ ' are the cross-sectional area, mass adsorbed and molar mass of the adsorbate respectively, then  $S = \left( \frac{m}{M} \right) A N_A$  ( $N_A$ -Avogadro's number)
  - The number of gas molecules physisorbed on unit mass of an adsorbent will be the same for two different gases at the same temperature.
  - Adsorption of  $\text{H}_2$  on Ni surface with  $E_a = 96 \text{ kJ mol}^{-1}$  can be termed as chemisorption
53. When excess  $\text{KMnO}_4$  is added to concentrated  $\text{H}_2\text{SO}_4$ , an oily green colored covalent compound **Y** is formed. Which of the following statements is/ are true for the above reaction.
- Compound **Y** is formed by a dehydration reaction
  - In compound **Y** Mn is octahedrally surrounded by oxygen atoms
  - Y** is the highest oxide of Manganese
  - Compound **Y** has Mn-O-Mn bridge
54. Read carefully all the three statements on defects in solids:
- In Frenkel defect, interstitial  $\text{Ag}^+$  site is surrounded tetrahedrally by four  $\text{Cl}^-$  ions and four  $\text{Ag}^+$  ions, where interstitial  $\text{Ag}^+$  and  $\text{Cl}^-$  interaction is covalent
  - Addition of small amount of  $\text{SrCl}_2$  in  $\text{NaCl}$  yields solid solution with a formula of  $\text{Na}_{1-2x}\text{Sr}_x\text{V}_{\text{Na}x}\text{Cl}$ , where  $V$  = valency
  - In general, Schottky defect increases the density of the substance

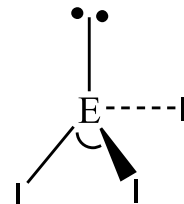
Choose the correct alternative(s).

- |   |   |
|---|---|
| (a) Statement (i) is correct            | (b) Statements (ii) and (iii) are correct |
| (c) Statements (i) and (ii) are correct | (d) Statements (i) and (iii) are correct  |

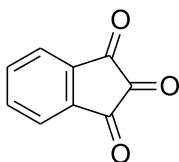
55. Eriochrome black T (EBT) is an indicator in titrimetric estimation of calcium at pH 10.0 giving pink colour to the solution. It has structure as shown below. Considering that the pH of solution is 10.0, which statement(s) describe(s) the complexation of EBT with Ca(II) correctly



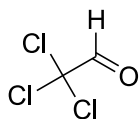
- (a) On dissociation of EBT, Ca(II) binds at  $\text{SO}_3^-$  to form 1:2 complex
- (b) Both sulphonate and nitro groups are involved in 1:1 complexation with Ca(II)
- (c) EBT acts as a bidentate ligand to form a dianionic species, with deprotonation of one  $-\text{OH}$ , where Ca(II) binds to azide nitrogen and phenolic oxygen *trans* to  $-\text{NO}_2$  group in 1:2 ratio
- (d) There is a mixture of complexes of Ca(II) with EBT acting as a bidentate and tridentate ligand
56. The correct statement(s) regarding three  $\text{EI}_3$  molecules (where E=P, As or Sb) is/are:
- (a) These compounds are formed by mutual sharing of electrons and hence considered as covalent compounds
- (b)  $\text{PI}_3$  is most susceptible towards hydrolysis in water to give phosphorous acid
- (c)  $\text{SbI}_3$  has highest boiling point amongst all
- (d) In  $\text{AsI}_3$ , there is least repulsion between bond pair and lone pair and thus has the largest I-E-I angle



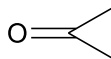
57. Aldehydes and ketones can react with water in the presence of an acid or base to yield an equilibrium mixture of the aldehyde/ketone and the corresponding hydrates (geminal diol). Among the following, the aldehyde/ketones which will have a greater percentage of the hydrate at equilibrium are



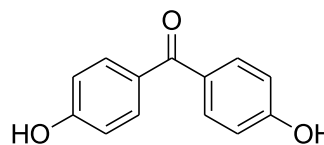
(a)



(b)

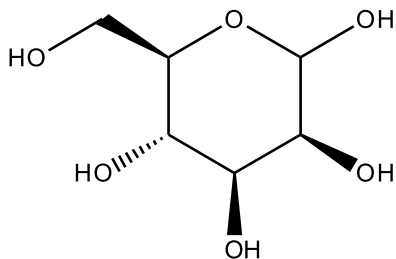


(c)



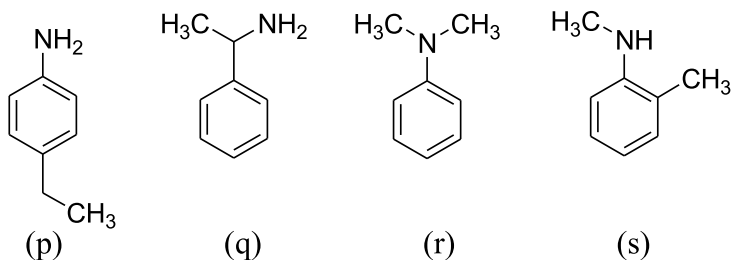
(d)

58. The correct statement/s about the pyranose form of a sugar (X) given below is/are:

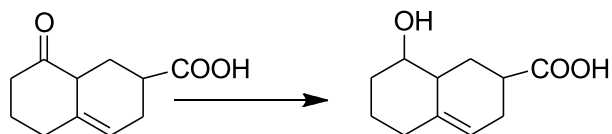


(X)

- (a) It exists in two anomeric pyranose forms  
 (b) It reacts with Tollens' reagent to give a silver mirror  
 (c) The penta-O-methyl derivative of (X) is non reducing.  
 (d) It resists reduction with aqueous sodium borohydride
59. Given below are isomeric amines. The **incorrect** statement/s about them from the following is/are



- (a) (p) and (q) both will give unstable products respectively with  $\text{NaNO}_2$  in  $\text{HCl}$  at 268 K  
 (b) Reaction of all amines with  $\text{HCl}$  is exothermic  
 (c) Reaction of benzene sulphonyl chloride with (s) gives a solid product that is soluble in  $\text{NaOH}$   
 (d) (q) has the highest basicity among these
60. Which one/s of the reduction techniques mentioned below is/are **NOT** suitable for the following chemical transformation



- (a)  $\text{NaBH}_4$  based reduction                      (b)  $\text{LiAlH}_4$  based reduction  
 (c) DIBAL-H based reduction                      (d)  $\text{B}_2\text{H}_6$  based reduction

## IUPAC Periodic Table of the Elements

1

|   |   |
|---|---|
| 1 | <b>H</b><br>hydrogen<br>1.008<br>[1.0078, 1.0082] |
|---|---|

Key:

|   |   |
|---|---|
| 3 | <b>Li</b><br>lithium<br>6.941<br>[6.938, 6.997] |
|---|---|

atomic number

|                            |
|----------------------------|
| <b>Symbol</b>              |
| conventional atomic weight |
| standard atomic weight     |

2

|   |                                  |
|---|----------------------------------|
| 4 | <b>Be</b><br>beryllium<br>9.0122 |
|---|----------------------------------|

3

|    |   |
|----|---|
| 21 | <b>Sc</b><br>scandium<br>44.956<br>[44.955, 44.957] |
|----|---|

4

|    |  |
|----|--|
| 22 | <b>Ti</b><br>titanium<br>47.88<br>[47.877, 47.883] |
|----|--|

5

|    |  |
|----|--|
| 23 | <b>V</b><br>vanadium<br>50.942<br>[50.941, 50.943] |
|----|--|

6

|    |   |
|----|---|
| 24 | <b>Cr</b><br>chromium<br>51.996<br>[51.995, 51.997] |
|----|---|

7

|    |  |
|----|--|
| 25 | <b>Mn</b><br>manganese<br>54.938<br>[54.937, 54.939] |
|----|--|

8

|    |   |
|----|---|
| 26 | <b>Fe</b><br>iron<br>55.845<br>[55.845, 55.845] |
|----|---|

9

|    |   |
|----|---|
| 27 | <b>Co</b><br>cobalt<br>58.933<br>[58.933, 58.933] |
|----|---|

10

|    |   |
|----|---|
| 28 | <b>Ni</b><br>nickel<br>58.693<br>[58.693, 58.693] |
|----|---|

11

|    |   |
|----|---|
| 29 | <b>Cu</b><br>copper<br>63.546<br>[63.546, 63.546] |
|----|---|

12

|    |  |
|----|--|
| 30 | <b>Zn</b><br>zinc<br>65.38<br>[65.38, 65.38] |
|----|--|

13

|    |  |
|----|--|
| 31 | <b>Ga</b><br>gallium<br>69.723<br>[69.723, 69.723] |
|----|--|

14

|    |   |
|----|---|
| 32 | <b>Ge</b><br>germanium<br>72.63<br>[72.63, 72.63] |
|----|---|

15

|    |  |
|----|--|
| 33 | <b>As</b><br>arsenic<br>74.922<br>[74.921, 74.923] |
|----|--|

16

|    |  |
|----|--|
| 34 | <b>Se</b><br>selenium<br>78.96<br>[78.96, 78.96] |
|----|--|

17

|    |  |
|----|--|
| 35 | <b>Br</b><br>bromine<br>79.904<br>[79.904, 79.904] |
|----|--|

18

|    |  |
|----|--|
| 36 | <b>Kr</b><br>krypton<br>83.798<br>[83.798, 83.798] |
|----|--|

19

|   |                               |
|---|-------------------------------|
| 2 | <b>He</b><br>helium<br>4.0026 |
|---|-------------------------------|

20

|    |   |
|----|---|
| 10 | <b>Ne</b><br>neon<br>20.180<br>[20.180, 20.180] |
|----|---|

21

|    |   |
|----|---|
| 11 | <b>Na</b><br>sodium<br>22.990<br>[22.989, 22.991] |
|----|---|

22

|    |  |
|----|--|
| 12 | <b>Mg</b><br>magnesium<br>24.305<br>[24.304, 24.307] |
|----|--|

23

|    |   |
|----|---|
| 13 | <b>Al</b><br>aluminum<br>26.982<br>[26.981, 26.983] |
|----|---|

24

|    |  |
|----|--|
| 14 | <b>Si</b><br>silicon<br>28.086<br>[28.085, 28.087] |
|----|--|

25

|    |  |
|----|--|
| 15 | <b>P</b><br>phosphorus<br>30.974<br>[30.973, 30.975] |
|----|--|

26

|    |   |
|----|---|
| 16 | <b>S</b><br>sulfur<br>32.06<br>[32.059, 32.061] |
|----|---|

27

|    |  |
|----|--|
| 17 | <b>Cl</b><br>chlorine<br>35.45<br>[35.446, 35.457] |
|----|--|

28

|    |  |
|----|--|
| 18 | <b>Ar</b><br>argon<br>39.948<br>[39.942, 39.963] |
|----|--|

29

|    |   |
|----|---|
| 19 | <b>K</b><br>potassium<br>39.098<br>[39.096, 39.100] |
|----|---|

30

|    |  |
|----|--|
| 20 | <b>Ca</b><br>calcium<br>40.078<br>[40.078, 40.078] |
|----|--|

31

|    |   |
|----|---|
| 21 | <b>Sc</b><br>scandium<br>44.956<br>[44.955, 44.957] |
|----|---|

32

|    |  |
|----|--|
| 22 | <b>Ti</b><br>titanium<br>47.88<br>[47.877, 47.883] |
|----|--|

33

|    |  |
|----|--|
| 23 | <b>V</b><br>vanadium<br>50.942<br>[50.941, 50.943] |
|----|--|

34

|    |   |
|----|---|
| 24 | <b>Cr</b><br>chromium<br>51.996<br>[51.995, 51.997] |
|----|---|

35

|    |  |
|----|--|
| 25 | <b>Mn</b><br>manganese<br>54.938<br>[54.937, 54.939] |
|----|--|

36

|    |   |
|----|---|
| 26 | <b>Fe</b><br>iron<br>55.845<br>[55.845, 55.845] |
|----|---|

37

|    |   |
|----|---|
| 27 | <b>Co</b><br>cobalt<br>58.933<br>[58.933, 58.933] |
|----|---|

38

|    |   |
|----|---|
| 28 | <b>Ni</b><br>nickel<br>58.693<br>[58.693, 58.693] |
|----|---|

39

|    |   |
|----|---|
| 29 | <b>Cu</b><br>copper<br>63.546<br>[63.546, 63.546] |
|----|---|

40

|    |  |
|----|--|
| 30 | <b>Zn</b><br>zinc<br>65.38<br>[65.38, 65.38] |
|----|--|

41

|    |  |
|----|--|
| 31 | <b>Ga</b><br>gallium<br>69.723<br>[69.723, 69.723] |
|----|--|

42

|    |   |
|----|---|
| 32 | <b>Ge</b><br>germanium<br>72.63<br>[72.63, 72.63] |
|----|---|

43

|    |  |
|----|--|
| 33 | <b>As</b><br>arsenic<br>74.922<br>[74.921, 74.923] |
|----|--|

44

|    |  |
|----|--|
| 34 | <b>Se</b><br>selenium<br>78.96<br>[78.96, 78.96] |
|----|--|

45

|    |  |
|----|--|
| 35 | <b>Br</b><br>bromine<br>79.904<br>[79.904, 79.904] |
|----|--|

46

|    |  |
|----|--|
| 36 | <b>Kr</b><br>krypton<br>83.798<br>[83.798, 83.798] |
|----|--|

47

|    |   |
|----|---|
| 37 | <b>Rb</b><br>rubidium<br>85.468<br>[85.468, 85.468] |
|----|---|

48

|    |   |
|----|---|
| 38 | <b>Sr</b><br>strontium<br>87.62<br>[87.62, 87.62] |
|----|---|

49

|    |   |
|----|---|
| 39 | <b>Y</b><br>yttrium<br>88.906<br>[88.906, 88.906] |
|----|---|

50

|    |  |
|----|--|
| 40 | <b>Zr</b><br>zirconium<br>91.224<br>[91.224, 91.224] |
|----|--|

51

|    |  |
|----|--|
| 41 | <b>Nb</b><br>niobium<br>92.906<br>[92.906, 92.906] |
|----|--|

52

|    |  |
|----|--|
| 42 | <b>Mo</b><br>molybdenum<br>95.94<br>[95.94, 95.94] |
|----|--|

53

|    |   |
|----|---|
| 43 | <b>Tc</b><br>technetium<br>98<br>[98, 98] |
|----|---|

54

|    |  |
|----|--|
| 44 | <b>Ru</b><br>ruthenium<br>101.07<br>[101.07, 101.07] |
|----|--|

55

|    |  |
|----|--|
| 45 | <b>Rh</b><br>rhodium<br>102.91<br>[102.91, 102.91] |
|----|--|

56

|    |  |
|----|--|
| 46 | <b>Pd</b><br>palladium<br>106.42<br>[106.42, 106.42] |
|----|--|

57

|    |   |
|----|---|
| 47 | <b>Ag</b><br>silver<br>107.87<br>[107.87, 107.87] |
|----|---|

58

|    |  |
|----|--|
| 48 | <b>Cd</b><br>cadmium<br>112.41<br>[112.41, 112.41] |
|----|--|

59

|    |   |
|----|---|
| 49 | <b>In</b><br>indium<br>114.82<br>[114.82, 114.82] |
|----|---|

60

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|----|--|
| 50 | <b>Sn</b><br>tin<br>118.71<br>[118.71, 118.71] |
|----|--|

61

|    |   |
|----|---|
| 51 | <b>Sb</b><br>antimony<br>121.76<br>[121.76, 121.76] |
|----|---|

62

|    |  |
|----|--|
| 52 | <b>Te</b><br>tellurium<br>127.60<br>[127.60, 127.60] |
|----|--|

63

|    |  |
|----|--|
| 53 | <b>I</b><br>iodine<br>126.90<br>[126.90, 126.90] |
|----|--|

64

|    |  |
|----|--|
| 54 | <b>Xe</b><br>xenon<br>131.29<br>[131.29, 131.29] |
|----|--|

65

|    |   |
|----|---|
| 55 | <b>Cs</b><br>cesium<br>132.91<br>[132.91, 132.91] |
|----|---|

66

|    |   |
|----|---|
| 56 | <b>Ba</b><br>barium<br>137.33<br>[137.33, 137.33] |
|----|---|

67

|    |  |
|----|--|
| 57 | <b>La</b><br>lanthanum<br>138.91<br>[138.91, 138.91] |
|----|--|

68

|    |   |
|----|---|
| 58 | <b>Ce</b><br>cerium<br>140.12<br>[140.12, 140.12] |
|----|---|

69

|    |   |
|----|---|
| 59 | <b>Pr</b><br>praseodymium<br>140.91<br>[140.91, 140.91] |
|----|---|

70

|    |  |
|----|--|
| 60 | <b>Nd</b><br>neodymium<br>144.24<br>[144.24, 144.24] |
|----|--|

71

|    |   |
|----|---|
| 61 | <b>Pm</b><br>promethium<br>144.91<br>[144.91, 144.91] |
|----|---|

72

|    |   |
|----|---|
| 62 | <b>Sm</b><br>samarium<br>150.36<br>[150.36, 150.36] |
|----|---|

73

|    |   |
|----|---|
| 63 | <b>Eu</b><br>europium<br>151.96<br>[151.96, 151.96] |
|----|---|

74

|    |   |
|----|---|
| 64 | <b>Gd</b><br>gadolinium<br>157.25<br>[157.25, 157.25] |
|----|---|

75

|    |  |
|----|--|
| 65 | <b>Tb</b><br>terbium<br>158.93<br>[158.93, 158.93] |
|----|--|

76

|    |   |
|----|---|
| 66 | <b>Dy</b><br>dysprosium<br>162.50<br>[162.50, 162.50] |
|----|---|

77

|    |  |
|----|--|
| 67 | <b>Ho</b><br>holmium<br>164.93<br>[164.93, 164.93] |
|----|--|

78

|    |   |
|----|---|
| 68 | <b>Er</b><br>erbium<br>167.26<br>[167.26, 167.26] |
|----|---|

79

|    |  |
|----|--|
| 69 | <b>Tm</b><br>thulium<br>168.93<br>[168.93, 168.93] |
|----|--|

80

|    |  |
|----|--|
| 70 | <b>Yb</b><br>ytterbium<br>173.05<br>[173.05, 173.05] |
|----|--|

81

|    |   |
|----|---|
| 71 | <b>Lu</b><br>lutetium<br>174.97<br>[174.97, 174.97] |
|----|---|

82

|    |  |
|----|--|
| 72 | <b>Hf</b><br>hafnium<br>178.49<br>[178.49, 178.49] |
|----|--|

83

|    |   |
|----|---|
| 73 | <b>Ta</b><br>tantalum<br>180.95<br>[180.95, 180.95] |
|----|---|

84

|    |  |
|----|--|
| 74 | <b>W</b><br>tungsten<br>183.84<br>[183.84, 183.84] |
|----|--|

85

|    |  |
|----|--|
| 75 | <b>Re</b><br>rhenium<br>186.21<br>[186.21, 186.21] |
|----|--|

86

|    |   |
|----|---|
| 76 | <b>Os</b><br>osmium<br>190.23<br>[190.23, 190.23] |
|----|---|

87

|    |  |
|----|--|
| 77 | <b>Ir</b><br>iridium<br>192.22<br>[192.22, 192.22] |
|----|--|

88

|    |   |
|----|---|
| 78 | <b>Pt</b><br>platinum<br>195.08<br>[195.08, 195.08] |
|----|---|

89

|    |   |
|----|---|
| 79 | <b>Au</b><br>gold<br>196.97<br>[196.97, 196.97] |
|----|---|

90

|    |  |
|----|--|
| 80 | <b>Hg</b><br>mercury<br>200.59<br>[200.59, 200.59] |
|----|--|

91

|    |   |
|----|---|
| 81 | <b>Tl</b><br>thallium<br>204.38<br>[204.38, 204.38] |
|----|---|

92

|    |  |
|----|--|
| 82 | <b>Pb</b><br>lead<br>207.2<br>[207.2, 207.2] |
|----|--|

93

|    |  |
|----|--|
| 83 | <b>Bi</b><br>bismuth<br>208.98<br>[208.98, 208.98] |
|----|--|

94

|    |  |
|----|--|
| 84 | <b>Po</b><br>polonium<br>209<br>[209, 209] |
|----|--|

95

|    |  |
|----|--|
| 85 | <b>At</b><br>astatine<br>210<br>[210, 210] |
|----|--|

96

|    |   |
|----|---|
| 86 | <b>Rn</b><br>radon<br>222<br>[222, 222] |
|----|---|

97

|    |  |
|----|--|
| 87 | <b>Fr</b><br>francium<br>223<br>[223, 223] |
|----|--|

98

|    |  |
|----|--|
| 88 | <b>Ra</b><br>radium<br>226<br>[226, 226] |
|----|--|

99

|    |  |
|----|--|
| 89 | <b>Ac</b><br>actinium<br>227<br>[227, 227] |
|----|--|

100

|    |  |
|----|--|
| 90 | <b>Th</b><br>thorium<br>232.04<br>[232.04, 232.04] |
|----|--|

101

|    |   |
|----|---|
| 91 | <b>Pa</b><br>protactinium<br>231.04<br>[231.04, 231.04] |
|----|---|

102

|    |   |
|----|---|
| 92 | <b>U</b><br>uranium<br>238.03<br>[238.03, 238.03] |
|----|---|

103

|    |  |
|----|--|
| 93 | <b>Np</b><br>neptunium<br>237.05<br>[237.05, 237.05] |
|----|--|

104

|    |  |
|----|--|
| 94 | <b>Pu</b><br>plutonium<br>244.06<br>[244.06, 244.06] |
|----|--|

105

|    |  |
|----|--|
| 95 | <b>Am</b><br>americium<br>243.06<br>[243.06, 243.06] |
|----|--|

106

|    |   |
|----|---|
| 96 | <b>Cm</b><br>curium<br>247.07<br>[247.07, 247.07] |
|----|---|

107

|    |  |
|----|--|
| 97 | <b>Bk</b><br>berkelium<br>247.07<br>[247.07, 247.07] |
|----|--|



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International Year  
of the Periodic Table  
of Chemical Elements



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# Rough Work





