



**INDIAN INSTITUTE OF SCIENCE  
BANGALORE - 560012**

**ENTRANCE TEST FOR ADMISSIONS - 2010**

**Program : Integrated Ph.D**  
**Entrance Paper : Chemical Sciences**  
**Paper Code : CS**

**Day & Date**  
**SUNDAY, 25<sup>TH</sup> APRIL 2010**

**Time**  
**2.00 P.M. TO 5.00 P.M.**

## INSTRUCTIONS

1. This question paper consists of only multiple-choice questions. All questions carry one mark each.
2. Answers are to be marked in the OMR sheet provided.
3. For each question, darken the appropriate bubble to indicate your answer.
4. Use only HB pencils for bubbling answers.
5. Mark only one bubble per question. If you mark more than one bubble, the answer will be evaluated as incorrect.
6. If you wish to change your answer, please erase the existing mark completely before marking the other bubble.
7. There will be **NEGATIVE** marking. **NEGATIVE** marking for each wrong answer will be 1/3.
8. A **PERIODIC TABLE** has been provided in the last page of this booklet.
9. Listed below are some useful physical constants:

(A) Universal gas constant	$R = 8.31451 \text{ J mol}^{-1} \text{ K}^{-1}$ $0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$
(B) Planck's constant,	$h = 6.626 \times 10^{-34} \text{ J.s}$
(C) Acceleration due to gravity	$g = 9.8 \text{ m s}^{-2}$
(D) Speed of light in vacuum	$c = 2.998 \times 10^8 \text{ m s}^{-1}$
(E) Avogadro's number	$N = 6.023 \times 10^{23} \text{ mol}^{-1}$
(F) Boltzmann constant	$k = 1.380 \times 10^{-23} \text{ J K}^{-1}$
(G) Electron charge	$e = 1.602 \times 10^{-19} \text{ C}$
(H) Electron mass	$m_e = 9.109 \times 10^{-31} \text{ Kg}$
(I) Permittivity of the vacuum	$\epsilon_0 = 8.854 \times 10^{-12} \text{ F m}^{-1}$
(J) Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
(K) 1 Calorie	$= 4.184 \text{ J}$
(L) 1 atm	$= 760 \text{ Torr}$
(M) 1 eV	$= 1.6022 \times 10^{-19} \text{ J}$

1. In the van der Waals equation shown below,

$$(P + n^2a/V^2)(V - nb) = nRT$$

which of the following gases has the highest value for  $b$ ?

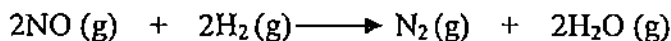
- (A) CH<sub>4</sub>  
 (B) CCl<sub>4</sub>  
 (C) CH<sub>2</sub>Cl<sub>2</sub>  
 (D) H<sub>2</sub>O
2. If aqueous solutions of the following salts were all prepared at the same molality, which solution would you expect to have the lowest freezing point?

- (A) NaCl  
 (B) Na<sub>2</sub>SO<sub>4</sub>  
 (C) CH<sub>3</sub>COONa  
 (D) Al(NO<sub>3</sub>)<sub>3</sub>

3. 98 % of a compound dissolved in 25 mL of water gets extracted into 50 mL of ethyl acetate. The distribution coefficient of the compound between ethyl acetate and water is:

- (A) 24.5  
 (B) 49  
 (C) 98  
 (D) 2

4. The method of initial rates is used to measure the rate law for the reaction given below:



The following initial rates are determined.  $P_A$  denotes the partial pressure of species A.

$P_{\text{NO}}$ (torr)	$P_{\text{H}_2}$ (torr)	Initial rate (torr/s)
200	400	0.46
400	200	0.92
400	400	1.85

The rate equation for the above process is:

- (A) Rate =  $k P_{\text{NO}}$   
 (B) Rate =  $k P_{\text{NO}}^2 P_{\text{H}_2}$   
 (C) Rate =  $k P_{\text{NO}} P_{\text{H}_2}^2$   
 (D) Rate =  $k P_{\text{NO}}^2 P_{\text{H}_2}^2$

5. Which of the following molecules will exhibit a pure rotational spectrum?

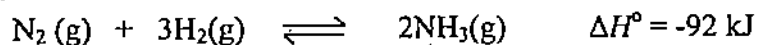
- (I) HCl
- (II) CH<sub>4</sub>
- (III) PF<sub>3</sub>

- (A) I only
- (B) II only
- (C) I and III only
- (D) III only

6. Copper sulphate spontaneously crystallizes out of a supersaturated solution on standing, or upon addition of a seed crystal. For this process, which of the following thermodynamic relations applies?

- (A)  $\Delta S < 0$  and  $\Delta H < 0$
- (B)  $\Delta S < 0$  and  $\Delta G > 0$
- (C)  $\Delta S > 0$  and  $\Delta H > 0$
- (D)  $\Delta S > 0$  and  $\Delta G < 0$

7. For the reaction,



which of the following conditions is most effective in driving the equilibrium to the right?

- (A) High pressure and low temperature
- (B) High pressure and high temperature
- (C) Low pressure and high temperature
- (D) Moderate pressure and the presence of a suitable catalyst

8. A radioactive isotope of copper, Cu<sup>64</sup>, decays via the reaction shown below:



The half-life of this reaction is 12.8 hours. Starting with 100 g of <sup>64</sup>Cu, how much <sup>64</sup>Zn will be produced in 51.2 hours?

- (A) 87.5 g
- (B) 94.25 g
- (C) 6.75 g
- (D) 75 g

9. A system of  $C$  components at fixed temperature and pressure exists in equilibrium in  $P$  phases. The total number of intensive variables that characterizes the system is:

- (A)  $CP + 2$
- (B)  $CP$
- (C)  $C - P + 2$
- (D)  $C(P + 2)$

10. When 1.0 kJ of energy is added to 5.0 L of an ideal gas, the gas expands against a constant external pressure of 1.0 bar to a final volume of 8.0 L. The change in internal energy,  $\Delta U$ , of the gas is: (you may assume that 1.0 L.bar = 0.1 kJ)

- (A) 0.3 kJ
- (B) 0.7 kJ
- (C) 1.0 kJ
- (D) 1.8 kJ

11. Which of the following characterizes the relationship between  $\beta$ , the volume thermal expansion coefficient of an isotropic solid, and  $\alpha$ , its linear thermal expansion coefficient?

- (A)  $\beta = \alpha^3$
- (B)  $\beta = 3\alpha$
- (C)  $\beta = \alpha/3$
- (D)  $\beta = \alpha^{1/3}$

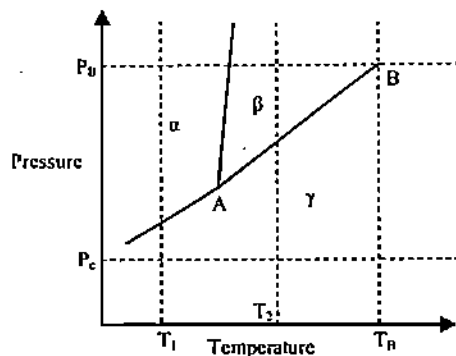
12. Which of the following is NOT a statement of the second law of thermodynamics?

- (A) Heat cannot be completely converted to work in a cyclic process.
- (B) In any cyclic process heat cannot be transferred from a cold reservoir to a hot reservoir without doing work.
- (C) In any spontaneous process, the entropy change is always positive.
- (D) In the neighbourhood of every equilibrium state, there are some states that cannot be reached by any adiabatic process.

13. The constant volume molar heat capacity  $C_v$  of a solid is approximately given by the formula  $C_v = aT^3$ , where  $a$  is a constant. What is the change in entropy of 7.8 g of Al when it is heated at constant volume from 10 K to 20 K?

- (A)  $700a$
- (B)  $7000a$
- (C)  $2333a$
- (D)  $1400a$

14. The figure below shows the phase diagram of a simple one-component system. Which of the following statements about this system is NOT true?



- (A) In state A of the system, none of the intensive variables can be varied independently.
- (B) At temperatures greater than  $T_B$ , no distinction can be made between the liquid and vapour phases of the system.
- (C) At the fixed pressure  $P_B$ , an increase in temperature from  $T_1$  to  $T_2$  leads to sublimation of the solid.
- (D) At the fixed temperature  $T_2$ , a decrease in pressure from  $P_B$  to  $P_C$  leads to evaporation of the liquid.
15. A weak acid HA has a  $K_a$  of  $1.00 \times 10^{-5}$ . If 0.100 moles of this acid is dissolved in 1 litre of water, the percentage of the acid dissociated at equilibrium is closest to:

- (A) 0.100 %  
(B) 1.00 %  
(C) 99.0 %  
(D) 99.9 %

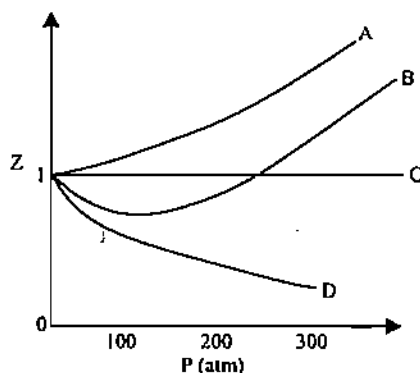
16. One litre of a 1 molar solution of  $\text{CuSO}_4$  is electrolyzed. After the passage of 1F of electricity, the molarity of  $\text{CuSO}_4$  in the solution will be:

- (A) 0.5 M  
(B) 0.25 M  
(C) 0.1 M  
(D) 0 M

17. If a plane in a cubic crystal intersects the  $a$ ,  $b$  and  $c$  axes at 1, 2 and infinity, respectively, its Miller indices will be :

- (A) (1 2 0)  
(B) (2 1 0)  
(C) (1 2  $\infty$ )  
(D) (2 1  $\infty$ )

18. The compressibility factor,  $Z$ , of a gas is defined as the ratio of the molar volume of the gas to the molar volume of an ideal gas at the same temperature  $T$  and pressure  $P$ . In the figure below,  $Z$  is plotted as a function of  $P$ .



Which of the four curves A, B, C or D most likely represents the behavior of nitrogen?

- (A) A  
 (B) B  
 (C) C  
 (D) D
19. A 0.01 M solution of HCl is placed in a cell whose cell constant is  $0.4 \text{ cm}^{-1}$ . The resistance of the solution is measured to be  $97.2 \Omega$ . The molar conductivity of the HCl solution is therefore:

- (A)  $411 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$   
 (B)  $0.00411 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$   
 (C)  $0.411 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$   
 (D)  $4.11 \Omega^{-1} \text{ cm}^2 \text{ mol}^{-1}$

20. The ratio of the diffusivity of gaseous methane to gaseous sulphur dioxide is:

- (A) 0.5  
 (B) 2  
 (C) 4  
 (D) 0.25
21. A compound alloy of gold and copper crystallizes in a cubic lattice in which the gold atoms occupy the lattice points at the corners of the cube and the copper atoms occupy the centres of each of the cube faces. The formula of this compound is therefore:

- (A)  $\text{AuCu}_3$   
 (B)  $\text{Au}_4\text{Cu}_3$   
 (C)  $\text{Au}_3\text{Cu}$   
 (D)  $\text{Au}_2\text{Cu}_3$

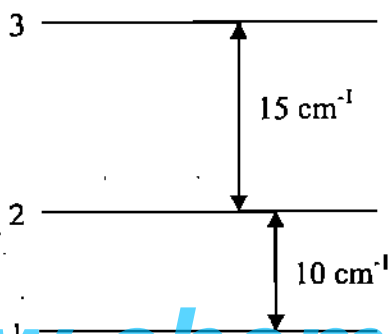
22. A sample of hemoglobin was found to contain 0.4% of Fe by weight. If the hemoglobin molecule contains 1 atom of Fe, what is the molecular weight of hemoglobin?

- (A) cannot be estimated
- (B) 14000 g/mol
- (C) 1400 g/mol
- (D) 140 g/mol

23. The wavelength of an electron accelerated through a potential of 100 kV is:

- (A) 37 Å
- (B) 3.7 Å
- (C) 0.037 Å
- (D) 0.37 Å

24. In the energy level diagram shown below,



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what is the wave number of the transition from level 1 to level 3?

- (A)  $150 \text{ cm}^{-1}$
- (B)  $25 \text{ cm}^{-1}$
- (C)  $5 \text{ cm}^{-1}$
- (D)  $6 \text{ cm}^{-1}$

25. Of the following molecules, which has the highest vibrational frequency (D and T stand for deuterium and tritium, respectively)?

- (A)  $\text{H}_2$
- (B) HD
- (C) HT
- (D)  $\text{D}_2$



26. Which of the following complexes shows a distorted octahedral geometry?

- (A)  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$
- (B)  $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$
- (C)  $[\text{Fe}(\text{H}_2\text{O})_6]^{2+}$
- (D)  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$

27. Which of the following compounds does not obey the EAN rule?

- (A)  $\text{Mn}_2(\text{CO})_{10}$
- (B)  $\text{Ru}(\eta^6\text{-C}_6\text{H}_6)_2$
- (C)  $\text{Cr}(\eta^6\text{-C}_6\text{H}_6)_2$
- (D)  $\text{Fe}(\text{CO})_5$

28. Which of the following molecules or ions has a square planar structure?

- (A)  $\text{CF}_4$
- (B)  $\text{XeF}_4$
- (C)  $\text{SeF}_4$
- (D)  $\text{BF}_4^-$

29. Which of the following catalysts is used for hydroformylation reactions?

- (A)  $\text{TiCl}_4 + \text{AlCl}_3$
- (B) Pt on asbestos
- (C)  $\text{RhCl}(\text{PPh}_3)_3$
- (D)  $\text{Co}_2(\text{CO})_8$

30. In which of the following molecules/ions are the bonds not all of equal length?

- (A)  $\text{SF}_4$
- (B)  $\text{SiF}_4$
- (C)  $\text{XeF}_4$
- (D)  $\text{BF}_4^-$

31. Among the following substituted silanes, the one which gives rise to a cross-linked silicone polymer upon hydrolysis is:

- (A)  $\text{R}_4\text{Si}$
- (B)  $\text{RSiCl}_3$
- (C)  $\text{R}_2\text{SiCl}_2$
- (D)  $\text{R}_3\text{SiCl}$

32. The amount of oxalic acid present in a solution can be determined by its titration with  $\text{KMnO}_4$  solution in the presence of  $\text{H}_2\text{SO}_4$ . But this method fails if the acid used in the titration is  $\text{HCl}$ . This is because  $\text{HCl}$

- (A) furnishes additional  $\text{H}^+$  ions apart from those from oxalic acid
- (B) gets oxidized by oxalic acid to chlorine
- (C) oxidizes oxalic acid to  $\text{CO}_2$
- (D) reduces permanganate to  $\text{Mn}^{2+}$

33. Which of the following represents a set of isoelectronic ions?

- (A)  $\text{Cl}^-$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{S}^{2-}$
- (B)  $\text{Cl}^-$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Sc}^{3+}$
- (C)  $\text{Na}^+$ ,  $\text{Li}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$
- (D)  $\text{N}^{3-}$ ,  $\text{F}^-$ ,  $\text{O}^{2-}$ ,  $\text{S}^{2-}$

34. The smallest cation among  $\text{Na}^+$ ,  $\text{Mg}^{2+}$ ,  $\text{Al}^{3+}$  and  $\text{K}^+$  is:

- (A)  $\text{Na}^+$
- (B)  $\text{Mg}^{2+}$
- (C)  $\text{Al}^{3+}$
- (D)  $\text{K}^+$

35. For the 4f subshell, what is the most positive value that the magnetic quantum number,  $m_l$ , can take?

- (A) +7
- (B) +3
- (C) +6
- (D) 0

36. The shape and geometry of  $\text{ICl}_2^-$  are, respectively,

- (A) trigonal and trigonal planar
- (B) linear and trigonal bipyramidal
- (C) trigonal and trigonal bipyramidal
- (D) linear and trigonal planar

37. The number of Mo – Mo bonds in  $[(\eta^5\text{-C}_5\text{H}_5)\text{Mo}(\text{CO})_2]_2^{2-}$  is:

- (A) zero
- (B) one
- (C) two
- (D) three

38. A Jahn-Teller distortion in  $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$  acts to

- (A) raise its symmetry
- (B) remove an electronic degeneracy
- (C) cause loss of an  $\text{H}_2\text{O}$  ligand
- (D) promote a  $d$  electron to an antibonding molecular orbital

39. The Ziegler-Natta catalyst for the polymerization of ethylene or propylene consists of  $\text{TiCl}_3$  and

- (A) an aluminum alkyl
- (B) titanium acetylacetonate
- (C) cobaltocene
- (D) diborane

40. The reaction of  $[(\eta^5\text{-C}_5\text{H}_5)\text{Fe}(\text{CH}_3)(\text{CO})_2]$  with  $\text{PPh}_3$  to give  $[(\eta^5\text{-C}_5\text{H}_5)\text{Fe}(\text{COCH}_3)(\text{CO})(\text{PPh}_3)]$  is an example of:

- (A) an oxidative addition
- (B) a reductive elimination
- (C) an insertion
- (D) an electron transfer

41.  $\text{C}_2\text{B}_{n-2}\text{H}_n$  is an isoelectronic analogue of :

- (A)  $\text{B}_n\text{H}_n$
- (B)  $\text{B}_n\text{H}_n^-$
- (C)  $\text{B}_n\text{H}_n^{3-}$
- (D)  $\text{B}_n\text{H}_n^{2-}$

42. Which of the four oxides of chlorine is paramagnetic?

- (A)  $\text{ClO}_2$
- (B)  $\text{Cl}_2\text{O}$
- (C)  $\text{Cl}_2\text{O}_4$
- (D)  $\text{Cl}_2\text{O}_6$

43. Which of the following diatomic species would you expect to have the smallest bond order?

- (A)  $\text{NO}^+$
- (B)  $\text{O}_2^-$
- (C)  $\text{CO}$
- (D)  $\text{N}_2^+$

44. Which of the following represents the order of variation of the maximum wavelength of absorption ( $\lambda_{max}$ ) of the complexes?

- (A)  $\text{FeF}_6 > \text{Fe}(\text{H}_2\text{O})_6 > \text{Fe}(\text{CN})_6$
- (B)  $\text{FeF}_6 > \text{Fe}(\text{CN})_6 > \text{Fe}(\text{H}_2\text{O})_6$
- (C)  $\text{Fe}(\text{CN})_6 > \text{FeF}_6 > \text{Fe}(\text{H}_2\text{O})_6$
- (D)  $\text{Fe}(\text{CN})_6 > \text{Fe}(\text{H}_2\text{O})_6 > \text{FeF}_6$

45. How many geometrical isomers exist for the complex  $[\text{Co}(\text{NH}_3)_3\text{Cl}_3]$ ?

- (A) six
- (B) four
- (C) two
- (D) one

46. The spin only magnetic moment of  $\text{K}_3[\text{Fe}(\text{CN})_6]$  is:

- (A) 1.73 BM
- (B) 4.9 BM
- (C) 0 BM
- (D) 2.8 BM

47. The products of the reaction of  $\text{NCl}_3$  with  $\text{H}_2\text{O}$  would be:

- (A)  $\text{N}(\text{OH})_3$  and  $\text{HCl}$
- (B)  $\text{NH}_3$  and  $\text{HOCl}$
- (C)  $\text{NH}_4\text{Cl}$  and  $\text{O}_2$
- (D)  $\text{N}_2\text{O}$  and  $\text{HCl}$

48. The chemical composition of the brown ring formed during the qualitative test for the nitrate anion is:

- (A)  $[\text{Fe}(\text{H}_2\text{O})_4(\text{NO})_2]\text{SO}_4$
- (B)  $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}_2]\text{SO}_4$
- (C)  $[\text{Fe}(\text{H}_2\text{O})_5\text{NO}_3]\text{SO}_4$
- (D)  $[\text{Fe}(\text{H}_2\text{O})_5(\text{NO})]\text{SO}_4$

49. The metal complex that is used in chemotherapy for cancer is:

- (A) *cis*- $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]$
- (B) *cis*- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$
- (C) *cis*- $[\text{Pt}(\text{NH}_3)_2\text{Cl}_4]$
- (D) *trans*- $[\text{Pt}(\text{NH}_3)_4\text{Cl}_2]$

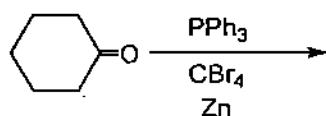
50. The correct order of hardness of the oxides CaO, BaO, MgO is:

- (A) CaO > BaO > MgO
- (B) BaO > CaO > MgO
- (C) MgO > CaO > BaO
- (D) MgO > BaO > CaO

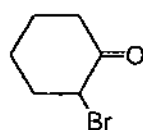
51. Methyl iodide and triethylamine will

- (A) react faster in ethanol than in hexane
- (B) react faster in hexane than in ethanol
- (C) react at the same rates in hexane and ethanol
- (D) will not react in either solvent

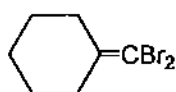
52. The major product of the following reaction



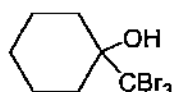
is:



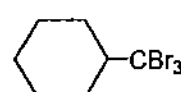
I



II



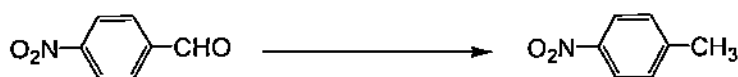
III



IV

- (A) I
- (B) II
- (C) III
- (D) IV

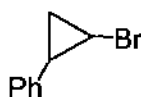
53. The most suitable reagent for the following conversion,



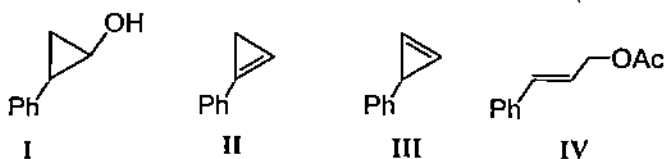
would be:

- (A)  $\text{H}_2$ , Pd-C, EtOH
- (B) Li,  $\text{NH}_3$  (liq),  $\text{NH}_4\text{Cl}$
- (C)  $\text{N}_2\text{H}_4$ , KOH, 1,2-dimethoxyethane
- (D)  $\text{LiAlH}_4$ ,  $\text{Et}_2\text{O}$

54. The following bromide,

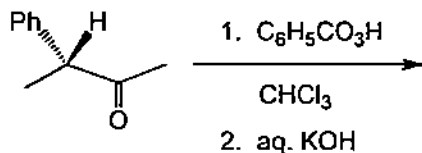


when heated with acetic acid will yield:



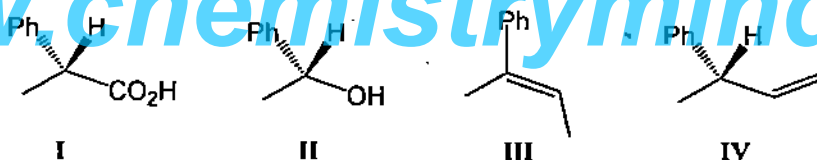
- (A) I
- (B) II
- (C) III
- (D) IV

55. The product of the following two-step reaction sequence,



would be:

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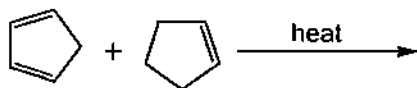


- (A) I
- (B) II
- (C) III
- (D) IV

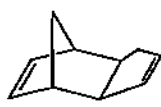
56. The correct IUPAC name of  $\text{Ph-CH}_2\text{-CH}_2\text{-COOH}$  is:

- (A) Styrene carboxylic acid
- (B) Phenethyl carboxylic acid
- (C) 2-Benzylacetic acid
- (D) 3-Phenylpropanoic acid

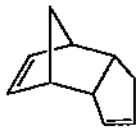
57. The major product of the reaction:



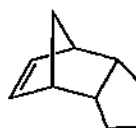
is:



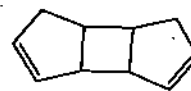
I



II



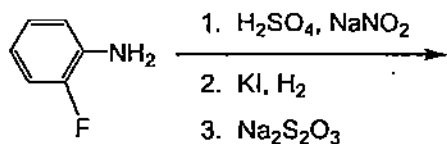
III



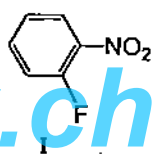
IV

- (A) I
- (B) II
- (C) III
- (D) IV

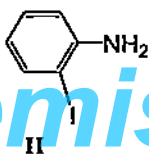
58. The following reaction sequence,



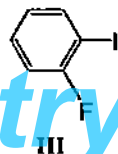
will yield:



I



II



III



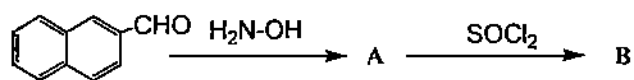
IV

- (A) I
- (B) II
- (C) III
- (D) IV

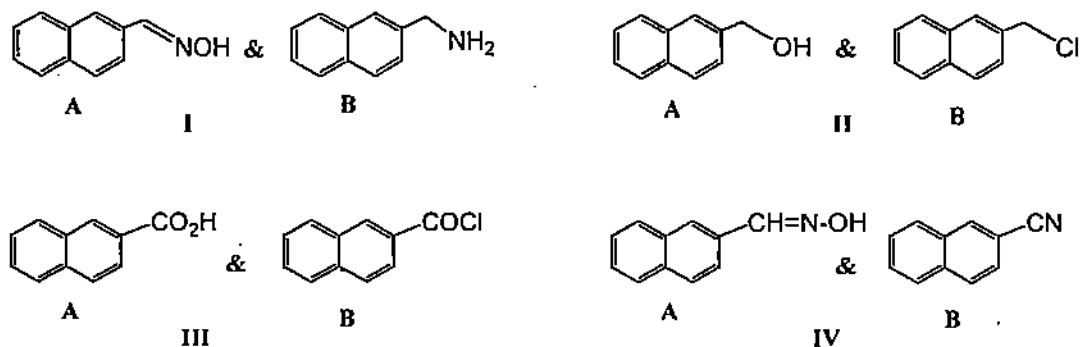
59. The products of ozonolysis ( $\text{O}_3, \text{H}_2\text{O}$ ) of vinyl chloride,  $\text{CH}_2=\text{CH}-\text{Cl}$ , are:

- (A)  $\text{HOCH}_2\text{CH}_2\text{Cl}$  and  $\text{H}_2\text{C}-\text{CH}(\text{OH})\text{Cl}$
- (B)  $\text{HCHO}$  and  $\text{ClCH}_2\text{OH}$
- (C)  $\text{HCHO}$ ,  $\text{CO}$  and  $\text{HCl}$
- (D)  $\text{HCO}_2\text{H}$ ,  $\text{CO}$  and  $\text{HCl}$

60. The reaction sequence shown below,

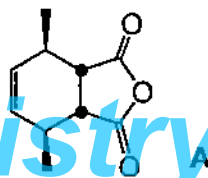


would yield:



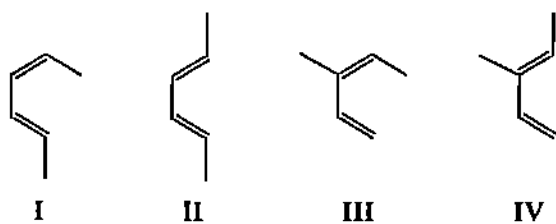
- (A) I  
 (B) II  
 (C) III  
 (D) IV

61. The compound A given below,



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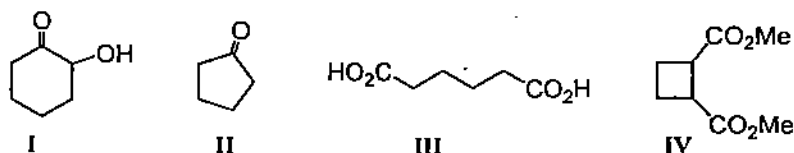
will be formed by reaction of maleic anhydride with:



- (A) I  
 (B) II  
 (C) III  
 (D) IV

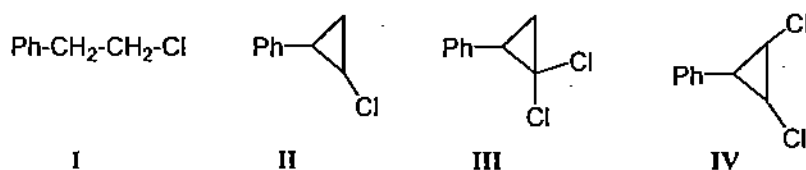


62. The product formed when the dimethyl ester of adipic acid reacts with excess sodium in toluene, followed by acidification, is:



- (A) I  
(B) II  
(C) III  
(D) IV

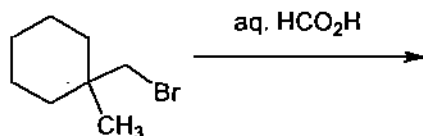
63. The product formed when styrene in  $\text{CHCl}_3$  is mixed with aq. NaOH and tetra-butyl ammonium chloride, is:



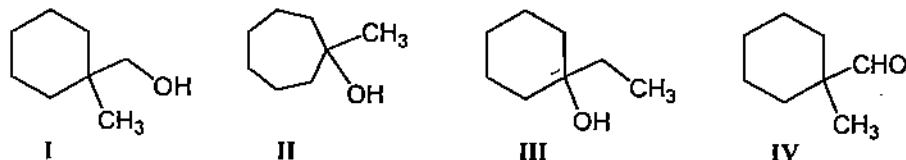
- (A) I  
(B) II  
(C) III  
(D) IV

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64. When the compound shown below,

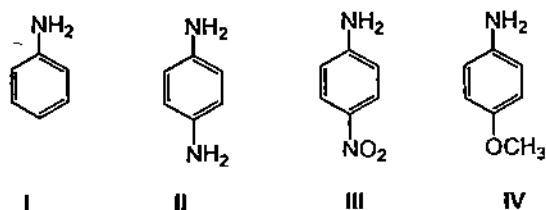


is reacted with aq. formic acid, the product formed would be:



- (A) I  
(B) II  
(C) III  
(D) IV

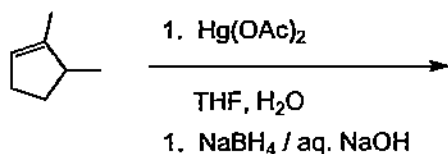
65. The basicities ( $pK_b$ ) of the following series of compounds (I-IV),



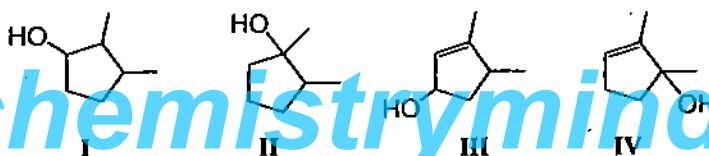
will vary as:

- (A) IV > II > I > III
- (B) III > I > IV > II
- (C) I > II > III > IV
- (D) IV > III > II > I

66. The major product of the following reaction,

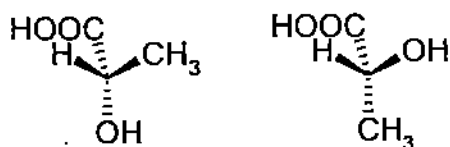


would be:



- (A) I
- (B) II
- (C) III
- (D) IV

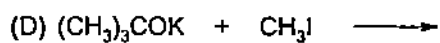
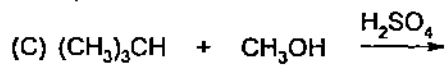
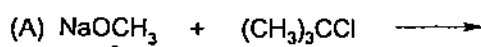
67. The structures shown below,



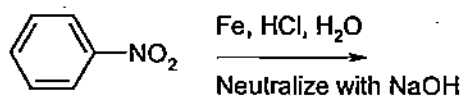
are:

- (A) identical
- (B) enantiomers
- (C) diastereomers
- (D) different conformations of the same compound

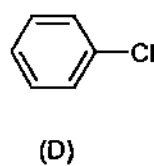
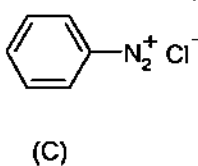
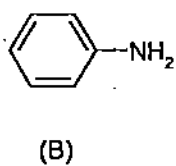
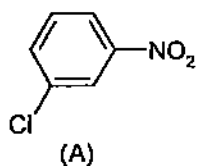
68. The reaction that produces  $(\text{CH}_3)_3\text{C-OCH}_3$  in highest yield is:



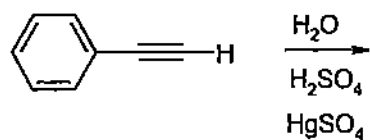
69. The following reaction,



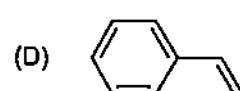
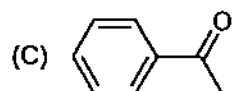
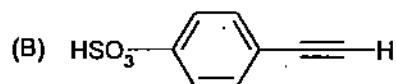
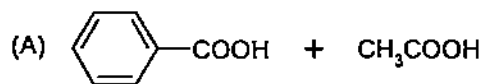
would yield:



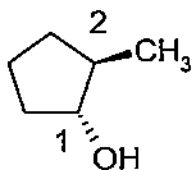
70. The major product in the following reaction



would be:



71. The structure of an optically active isomer of 2-methylcyclopentanol is shown below.



The absolute configuration of this isomer is:

(A) 1R, 2R

(B) 1S, 2S

(C) 1S, 2R

(D) 1R, 2S

72. How many *mono* nitro derivatives can be obtained by the nitration of m-xylene?

(A) 1

(B) 2

(C) 3

(D) 4

73. Zinc dust is used as one of the reagents in which of the following reactions?

(A) Gignard reaction

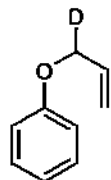
(B) Catalytic hydrogenation

(C) Acyloin condensation

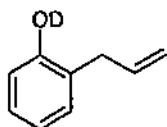
(D) Reformatsky reaction

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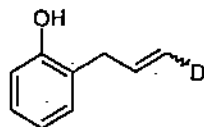
74. Upon heating, the following labeled allyl phenyl ether,



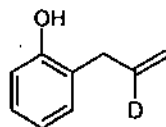
rearranges to:



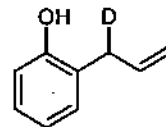
A



B



C



D

75. Tyrosine, aspartic acid and lysine are examples, respectively, of:

- (A) acidic, basic and aromatic amino acids
- (B) basic, acidic and aromatic amino acids
- (C) aromatic, acidic and basic amino acids
- (D) basic, aromatic and acidic amino acids

76. A parallel plate capacitor carries a charge  $Q$  at a voltage of  $V$ . If an additional dielectric is introduced between the plates of the capacitor, then:

- (A) the charge will remain the same but the voltage will decrease
- (B) the charge will decrease but the voltage will remain the same
- (C) both voltage and charge will increase
- (D) both voltage and charge will decrease

77. A ball is projected with a speed of 10 m/s at an angle of  $45^\circ$  from a point on the ground. The time in seconds after which its velocity becomes perpendicular to the velocity of projection is:

- (A) 0.5 s
- (B)  $\sqrt{2}$  s
- (C)  $1/\sqrt{2}$  s
- (D) 1 s

78. If  $x = r \sin\theta \cos\phi$ ,  $y = r \sin\theta \sin\phi$  and  $z = r \cos\theta$ , then the value of  $x^2 + y^2 + z^2$  is independent of:

- (A)  $\theta$  and  $\phi$
- (B)  $r$  and  $\theta$
- (C)  $r$  and  $\phi$
- (D)  $r$

79.  $\int 5x e^{2x} dx$  is:

- (A)  $(5/2)e^{2x} - (5/4)e^{2x} + C$
- (B)  $x e^x - (5/2)e^{2x} + C$
- (C)  $(5/8)e^{2x} - (3/2)e^x - 5 + C$
- (D)  $e^{2x} - e^{2x} + C$

80. The unit vector in the direction of  $\mathbf{a} = 3\mathbf{i} + 2\mathbf{j} + 5\mathbf{k}$  is:

- (A)  $(5/\sqrt{38})\mathbf{i} + (3/\sqrt{38})\mathbf{j} + (2/\sqrt{38})\mathbf{k}$
- (B)  $(3/\sqrt{38})\mathbf{i} + (2/\sqrt{38})\mathbf{j} + (3/\sqrt{38})\mathbf{k}$
- (C)  $(3/\sqrt{18})\mathbf{i} + (2/\sqrt{28})\mathbf{j} + (3/\sqrt{38})\mathbf{k}$
- (D)  $(3/\sqrt{3})\mathbf{i} + (2/\sqrt{2})\mathbf{j} + (3/\sqrt{5})\mathbf{k}$

81. The series:  $1 + \frac{1}{4} - \frac{1}{16} - \frac{1}{64} + \frac{1}{256} + \frac{1}{1024} - - + \dots$ , can be summed to the value:

- (A) 20/17
- (B) 23/20
- (C) 13/11
- (D) 18/15

82. If  $y(x)$  is some function of  $x$  and  $y'(x)$  stands for  $\frac{dy}{dx}$ , the solution of the differential equation:  $\ln[y(x)y'(x)] = x$ , under the initial condition  $y(0) = 0$ , is given by:

- (A)  $y(x) = \sqrt{2(e^x - 1)}$
- (B)  $y(x) = 1 - e^{x/2}$
- (C)  $y(x) = \frac{1}{2}(e^x - 1)$
- (D)  $y(x) = \frac{1}{\sqrt{2}}(1 - e^x)$

83. The value of  $d^n/dx^n (\sin(ax))$  is:

- (A)  $a^n \sin(ax + n\pi/2)$
- (B)  $a^n \cos(ax + n\pi/2)$
- (C)  $a^n \sin(ax + n\pi)$
- (D)  $a^n \cos(ax + n\pi)$

84. If  $u = 1 + i$  (where  $i = \sqrt{-1}$ ) then the value of  $u^{25}$  is:

- (A)  $2048(1+i)$
- (B)  $4096 \times \sqrt{2}(1+i)$
- (C)  $4096(1+i)$
- (D)  $2048 \times \sqrt{2}(1+i)$

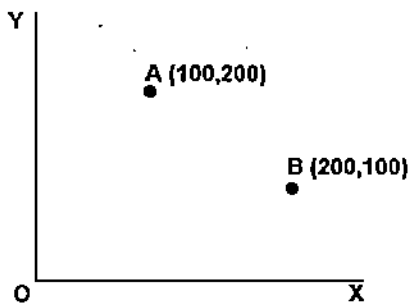
85. A man carrying weights in his outstretched hands stands at the centre of a circular platform that is rotating freely at constant angular velocity about its central axis. If he draws the weights inwards, towards his body while the platform is in motion, then:

- (A) the angular velocity of the system will increase
- (B) the angular velocity of the system will decrease
- (C) the angular momentum of the system will increase
- (D) the angular momentum of the system will decrease

86. A curve is specified by the parametric equations:  $x = \cos(t)$ ,  $y = \sin(t)$  and  $z = t$ . The vector tangent to the curve at the point  $(1, 0, 2\pi)$  is:

- (A)  $\mathbf{a} = \mathbf{j} - \mathbf{k}$
- (B)  $\mathbf{a} = \mathbf{i} + \mathbf{j} - \mathbf{k}$
- (C)  $\mathbf{a} = \mathbf{i} + \mathbf{j} + \mathbf{k}$
- (D)  $\mathbf{a} = \mathbf{j} + \mathbf{k}$

87. In a certain competition, each participant must start from the point A and reach the point B (the coordinates of these points with respect to the point O are shown below) by running to and touching both the walls OX and OY in any order.



The shortest distance by which a participant can achieve this is:

- (A)  $100\sqrt{6}$  meters
- (B)  $300\sqrt{2}$  meters
- (C)  $100\sqrt{2}$  meters
- (D)  $200\sqrt{5}$  meters

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88. If

$$D(x) = \begin{vmatrix} 1 & x & x^2 \\ x^2 & 1 & x \\ x & x^2 & 1 \end{vmatrix}$$

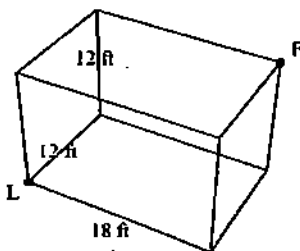
Then  $D(\omega)$ , where  $\omega =$  any one of the three cube roots of 1 (i.e.  $\omega$  satisfies  $\omega^3 = 1$ ), is:

- (A)  $\omega - 1$
- (B) 0
- (C)  $\omega$
- (D)  $\omega^2$

89. A metal sphere of radius  $R$  has a charge  $Q$ . The electrostatic potential at a distance  $r$  from the centre of the sphere is denoted  $V(r)$ . Then  $V(r)$  is given by:

- (A)  $V(r) = Q/(4 \pi \epsilon_0 r)$  everywhere
- (B)  $V(r) = Q/(4 \pi \epsilon_0 r)$  if the point is outside the sphere and  $V(r) = 0$  inside the sphere.
- (C)  $V(r) = Q/(4 \pi \epsilon_0 r)$  if the point is outside the sphere and  $V(r) = Q/(4 \pi \epsilon_0 R)$  if it is inside the sphere
- (D)  $V(r) = Q^2/(4 \pi \epsilon_0 r)$  if the point is outside the sphere and  $V(r) = 0$  inside the sphere.

90. A fly (F) is sitting at a corner of a room of dimensions  $18\text{ ft} \times 12\text{ ft} \times 12\text{ ft}$  (see Figure below) at the point marked F. A lizard (L) is sitting at the diagonally opposite corner.



The minimum distance that the lizard has to cross (it cannot fly!) to reach the fly is:

- (A)  $30\text{ ft}$
- (B)  $6\sqrt{5}(1+\sqrt{2})\text{ ft}$
- (C)  $(12 + \sqrt{468})\text{ ft}$
- (D)  $(18 + 12\sqrt{2})\text{ ft}$

91. A satellite is orbiting earth at a distance  $R$  from the centre of the earth. If the acceleration due to earth's gravity is  $g$  at that distance, then the orbital velocity is given as:

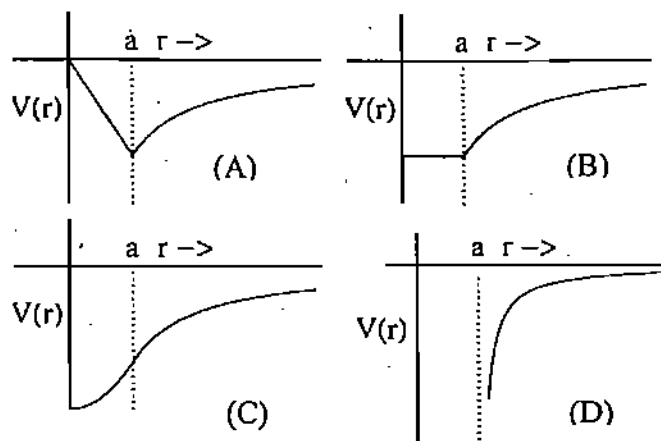
- (A)  $\sqrt{gR}$
- (B)  $\sqrt{2gR}$
- (C)  $\sqrt{g/R}$
- (D)  $\sqrt{g/2R}$



92. In the photoelectric effect, it is observed that the kinetic energy of the ejected photoelectrons is independent of:

- (A) work function of the metal
- (B) frequency of the incident radiation
- (C) intensity of the incident radiation
- (D) wavelength of the incident radiation

93. P is a point at a distance  $r$  from the centre of a sphere of radius  $a$ . The gravitational potential at the point P is  $V(r)$ . If  $V(r)$  is plotted against  $r$ , the resulting curve would be given by (see Figure below):



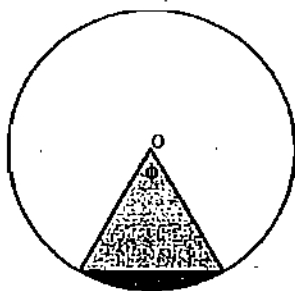
94. A wire of resistance  $10\Omega$  is drawn to thrice its original length. The resistance of the drawn wire will be:

- (A)  $30\Omega$
- (B)  $90\Omega$
- (C)  $3.33\Omega$
- (D)  $1.11\Omega$

95. Unpolarized light passes through three polarizing filters. The axis of the second one is at an angle of  $+30^\circ$  with respect to the first, and the axis of the third is at an angle  $+30^\circ$  with respect to the second. The fraction of the original intensity that emerges from the third polarizer is:

- (A)  $9/32$
- (B)  $3/8$
- (C)  $2/9$
- (D)  $1/8$

96. In the figure below, O is the center of a circle of radius  $r$ . Consider the ratio:  $f = (\text{area of the dark shaded region})/(\text{area of the light shaded region})$ .



As the angle  $\phi$  approaches zero, the value of  $f$  approaches:

- (A) 0
  - (B)  $1/(3r)$
  - (C)  $1/3$
  - (D)  $\infty$
97. From a group of 3 women and 4 men, the number of different committees that can be formed consisting of 1 woman and 2 men is:

- (A) 18
- (B) 9
- (C) 12
- (D) 36

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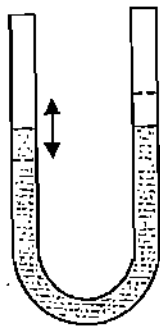
98. When a monochromatic light beam enters a medium of refractive index 2,

- (A) its frequency is doubled
- (B) its frequency is halved
- (C) its speed is doubled
- (D) its speed is halved

99. An explosion blows a rock into three pieces. Two pieces go off at right angles to each other with masses 2.0 kg and 4.0 kg, having velocities 6.0 m/s and 4.0 m/s, respectively. If the third piece flies with a velocity of 20.0 m/s, its mass will be:

- (A) 0.5 kg
- (B) 1.0 kg
- (C) 0.8 kg
- (D) 1.5 kg

100. A U tube has a liquid in it. The total length of the liquid column inside it is  $l$ . After the levels on the two arms have attained the same level, the liquid surface on one of the levels is pushed down slightly and released.  $g$  denotes acceleration due to gravity and  $\rho$  the density of the liquid.



The liquid will execute simple harmonic motion with a time period of:

- (A)  $2\pi\sqrt{l/g}$
- (B)  $2\pi\sqrt{2l/g}$
- (C)  $2\pi\sqrt{l/(g^2)}$
- (D)  $2\pi\sqrt{l/(2g\rho)}$

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Hydrogen 1 H																	Helium 2 He	
Lithium 3 Li	Beryllium 4 Be											Boron 5 B	Carbon 6 C	Nitrogen 7 N	Oxygen 8 O	Fluorine 9 F	Neon 10 Ne	
Sodium 11 Na	Magnesium 12 Mg											Aluminum 13 Al	Silicon 14 Si	Phosphorus 15 P	Sulfur 16 S	Chlorine 17 Cl	Argon 18 Ar	
Potassium 19 K	Calcium 20 Ca	Scandium 21 Sc	Titanium 22 Ti	Vanadium 23 V	Chromium 24 Cr	Manganese 25 Mn	Iron 26 Fe	Cobalt 27 Co	Nickel 28 Ni	Copper 29 Cu	Zinc 30 Zn	Gallium 31 Ga	Germanium 32 Ge	Arsenic 33 As	Selenium 34 Se	Bromine 35 Br	Krypton 36 Kr	
Rubidium 37 Rb	Strontium 38 Sr	Yttrium 39 Y	Zirconium 40 Zr	Niobium 41 Nb	Molybdenum 42 Mo	Technetium 43 Tc	Ruthenium 44 Ru	Rhodium 45 Rh	Palladium 46 Pd	Silver 47 Ag	Cadmium 48 Cd	Indium 49 In	Sn 50	Sb 51	Te 52	Iodine 53 I	Xenon 54 Xe	
Cesium 55 Cs	Barium 56 Ba	* 57-70	Lanthanum 57 Lu	Hafnium 72 Hf	Tantalum 73 Ta	Tungsten 74 W	Rhenium 75 Re	Osmium 76 Os	Iridium 77 Ir	Platinum 78 Pt	Gold 79 Au	Mercury 80 Hg	Thallium 81 Tl	Lead 82 Pb	Bismuth 83 Bi	Po 84	Astatine 85 At	Rn 86
Francium 87 Fr	Radium 88 Ra	* * 89-102	Actinium 89 Ac	Thorium 90 Th	Protactinium 91 Pa	Uranium 92 U	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102		

\* Lanthanide series

\* Actinide series

Lanthanum 57 La	Cerium 58 Ce	Praseodymium 59 Pr	Niodymium 60 Nd	Promethium 61 Pm	Samarium 62 Sm	Europium 63 Eu	Gadolinium 64 Gd	Terbium 65 Tb	Dysprosium 66 Dy	Ho 67	Er 68	Tm 69	Yb 70
Actinium 89 Ac	Thorium 90 Th	Protactinium 91 Pa	Uranium 92 U	Np 93	Pu 94	Am 95	Cm 96	Bk 97	Cf 98	Es 99	Fm 100	Md 101	No 102

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