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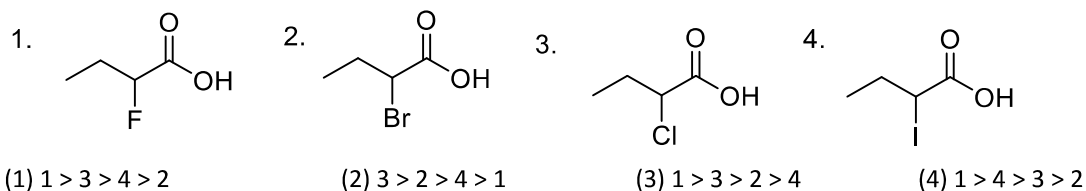
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Chapter 1

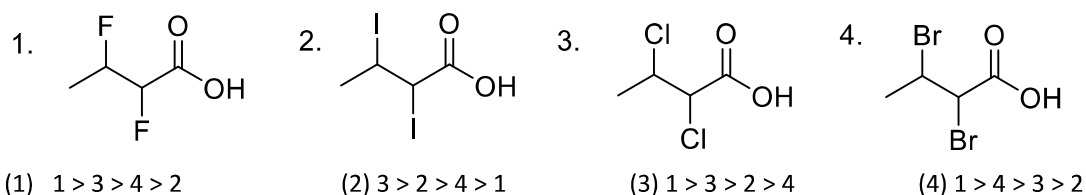
General Organic Chemistry

1.1. Concept Check

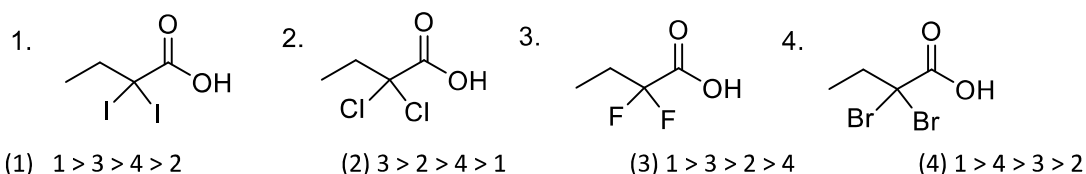
1. Arrange the molecules with decreasing order of acidity?



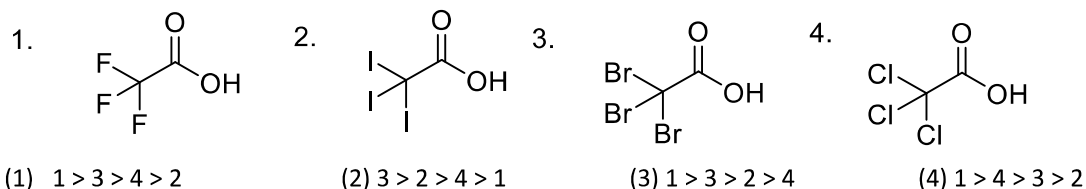
2. Arrange the molecules with decreasing order of acidity?



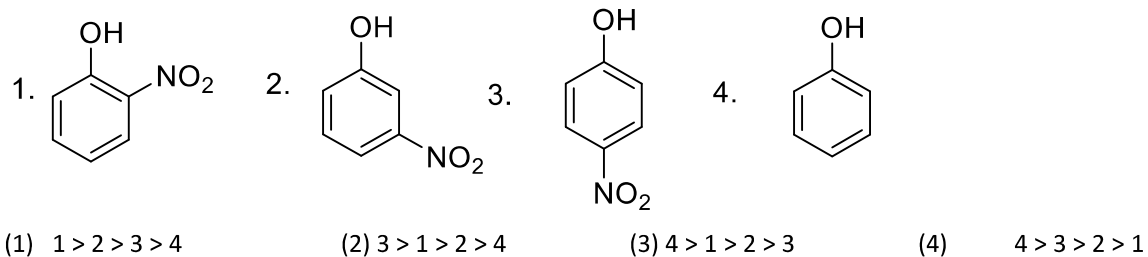
3. Arrange the molecules with decreasing order of acidity?



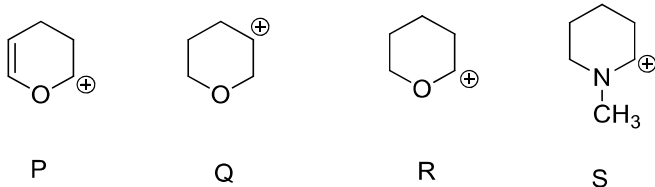
4. Arrange the molecules with decreasing order of acidity?



5. Arrange the molecules with decreasing order of acidity?



6. The correct order of the stability of carbocation is



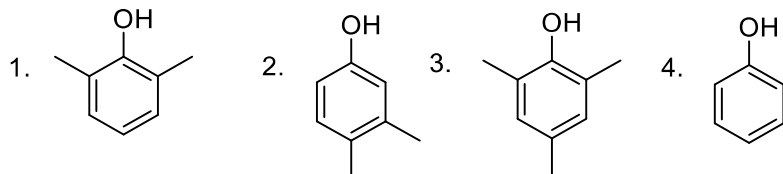
(1) $P > R > Q > S$

(2) $S > R > Q > P$

(3) $S > P > R > Q$

(4) $S > R > P > Q$

7. Arrange the molecules with decreasing order of acidity



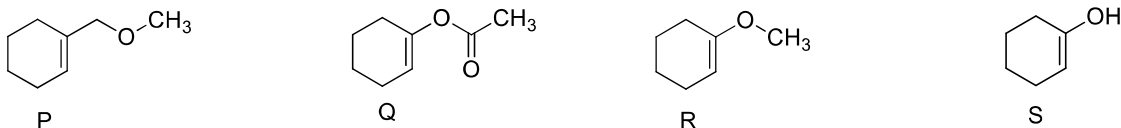
(1) $1 > 2 > 3 > 4$

(2) $3 > 1 > 2 > 4$

(3) $3 > 2 > 1 > 4$

(4) $4 > 2 > 1 > 3$

8. The correct order of the reactivity of alkene towards electrophile



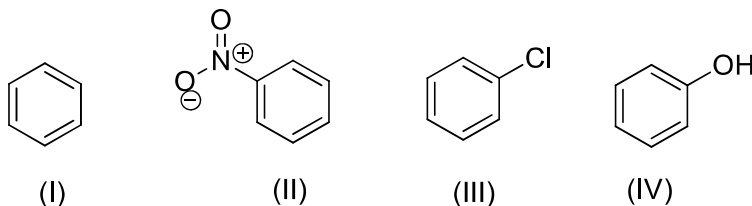
(1) $S > R > P > Q$

(2) $S > P > R > Q$

(3) $R > S > Q > P$

(4) $S > R > Q > P$

9. The increasing order of reactivity of the following compounds towards $\text{HNO}_3/\text{H}_2\text{SO}_4$ is:



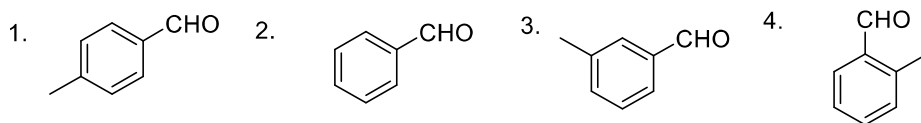
(1) $\text{II} < \text{I} < \text{III} < \text{IV}$

(2) $\text{I} < \text{II} < \text{IV} < \text{III}$

(3) $\text{II} < \text{I} < \text{IV} < \text{III}$

(4) $\text{I} < \text{II} < \text{III} < \text{IV}$

10. Arrange the molecules with decreasing order of reactivity towards nucleophile?



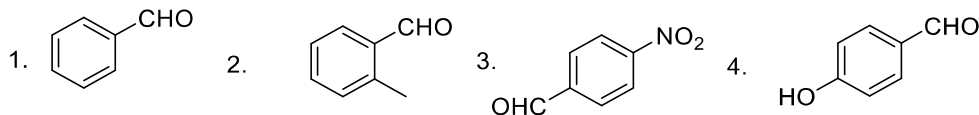
(1) $2 > 3 > 4 > 1$

(2) $2 > 3 > 1 > 4$

(3) $3 > 1 > 2 > 4$

(4) $4 > 3 > 1 > 2$

11. Arrange the molecules with decreasing order of reactivity toward's nucleophile?



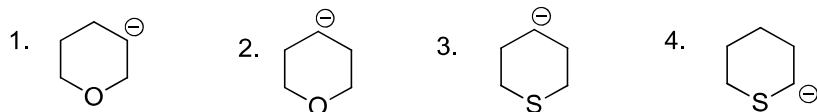
(1) $2 > 3 > 4 > 1$

(2) $3 > 1 > 2 > 4$

(3) $3 > 2 > 1 > 4$

(4) $4 > 3 > 1 > 2$

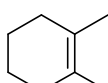
12. Which of the following carbanion is most stable?



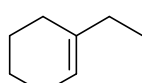
13. Arrange the stability of following?



I



II



III

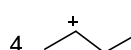
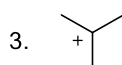
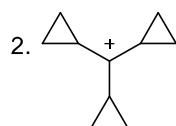
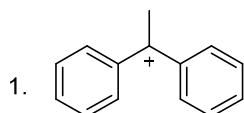
(1) I < II < III

(2) II < I < III

(3) I < III < II

(4) II < III < I

14. Arrange the decreasing order of the following cation?



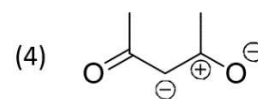
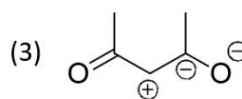
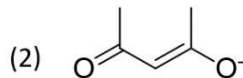
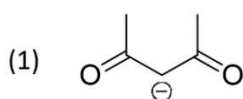
(1) 1 > 2 > 3 > 4

(2) 2 > 3 > 4 > 1

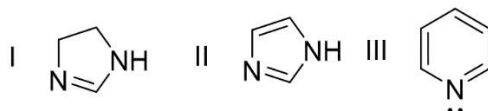
(3) 3 > 4 > 1 > 2

(4) 2 > 1 > 3 > 4

15. Which is the most stable resonating structure?



16. The correct order of basicity in following compounds is



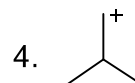
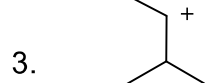
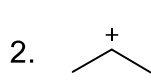
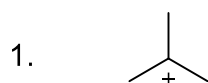
(1) III > I > II

(2) III > II > I

(3) I > III > II

(4) I > II > III

17. Arrange the decreasing order of the following carbocation?



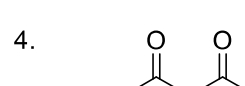
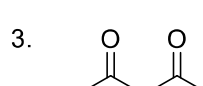
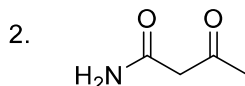
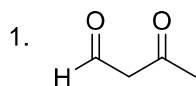
(1) 1 > 2 > 3 > 4

(2) 2 > 3 > 4 > 1

(3) 3 > 4 > 1 > 2

(4) 2 > 1 > 3 > 4

18. Acidity order?



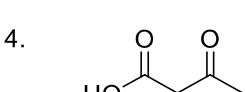
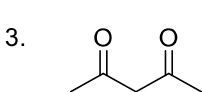
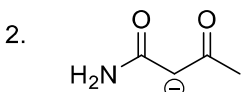
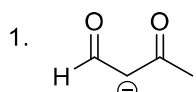
(1) 1 > 2 > 3 > 4

(2) 4 > 1 > 3 > 2

(3) 4 > 2 > 1 > 3

(4) 4 > 3 > 2 > 1

19. Basicity order



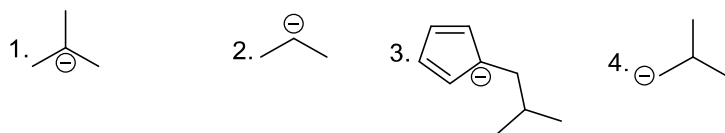
(1) 1 > 2 > 3 > 4

(2) 2 > 3 > 1 > 4

(3) 2 > 4 > 3 > 1

(4) 4 > 3 > 2 > 1

20. Arrange the decreasing order of the following Anion?



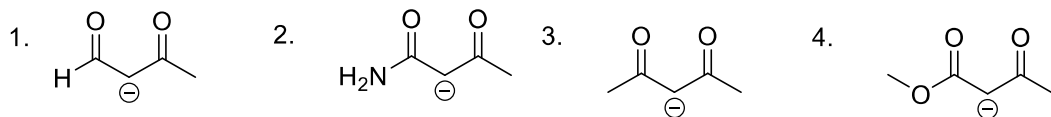
(1) $1 > 2 > 3 > 4$

(2) $2 > 3 > 4 > 1$

(3) $3 > 4 > 2 > 1$

(4) $2 > 1 > 3 > 4$

21. Basicity order



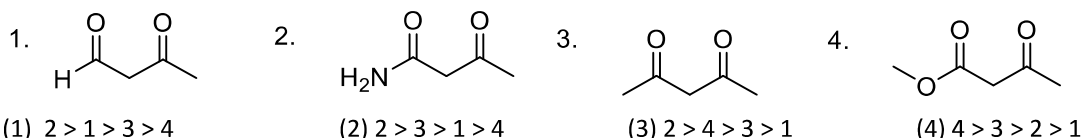
(1) $1 > 2 > 3 > 4$

(2) $2 > 3 > 1 > 4$

(3) $2 > 4 > 3 > 1$

(4) $4 > 3 > 2 > 1$

22. Acidity order



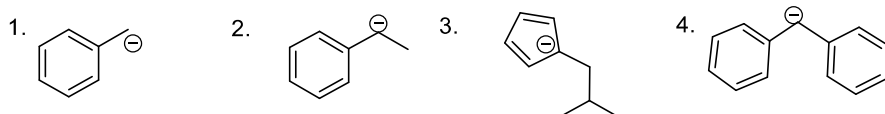
(1) $2 > 1 > 3 > 4$

(2) $2 > 3 > 1 > 4$

(3) $2 > 4 > 3 > 1$

(4) $4 > 3 > 2 > 1$

23. Arrange the decreasing order of the following Anion?



(1) $1 > 2 > 3 > 4$

(2) $2 > 3 > 4 > 1$

(3) $3 > 4 > 2 > 1$

(4) $3 > 4 > 1 > 2$

24. Which one of the following groups shows maximum -I effect?

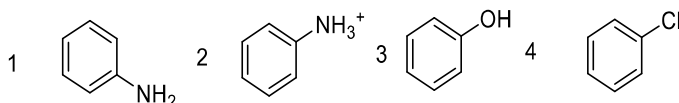
(1) NH_3^+

(2) NH_2Me^+

(3) NHMe_2^+

(4) NMe_3^+

25. In which of the following molecule, the resonance effect is not present?



26. Which of the following order is not the correct order regarding -I effect of the substituents?

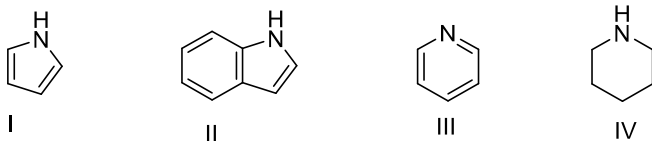
(1) $-\text{I} < -\text{Cl} < -\text{Br} < -\text{F}$

(2) $-\text{NR} < -\text{O}^+\text{R}_2$

(3) $-\text{NR} < -\text{OR} < -\text{F}$

(4) $-\text{SR} < -\text{OR} < -\text{O}^+\text{R}_2$

27. Increasing order of basicity of the following molecules is,



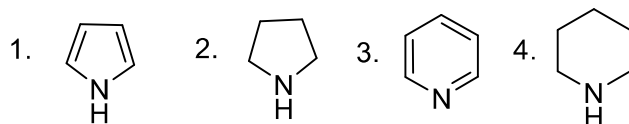
(1) $\text{I} < \text{II} < \text{III} < \text{IV}$

(2) $\text{II} < \text{III} < \text{IV} < \text{I}$

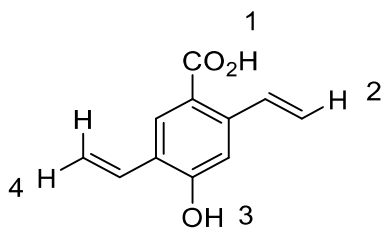
(3) $\text{II} < \text{I} < \text{III} < \text{IV}$

(4) $\text{II} < \text{I} < \text{IV} < \text{III}$

28. Which of the following is the strongest base water?

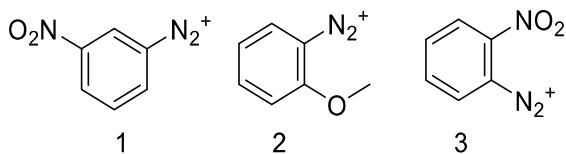


29. Which Hydrogen is the most acidic ?



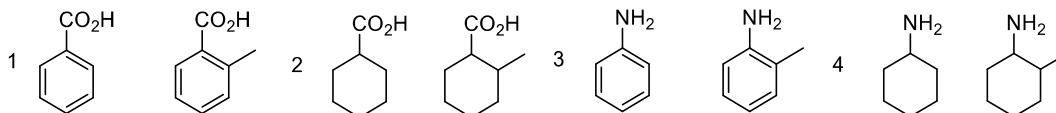
- (1) (I) (2) (II) (3) (III) (4) (IV)

30. Arrange the following electrophiles in the decreasing order of the electrophilicity?

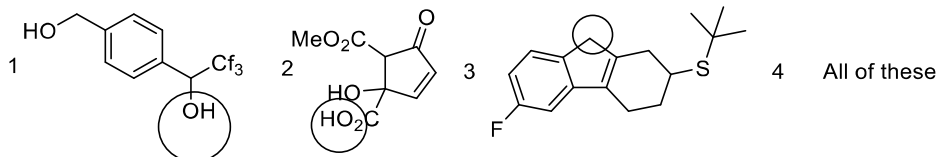


- (1) $3 > 1 > 2$ (2) $2 > 3 > 1$ (3) $3 > 2 > 1$ (4) $1 > 2 > 3$

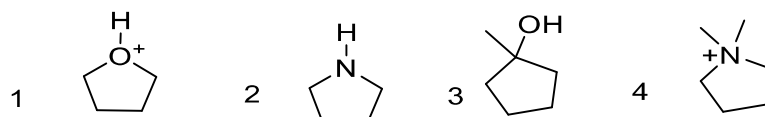
31. Find out the most acidic and basic pair from 1 & 2 and 3 & 4 respectively



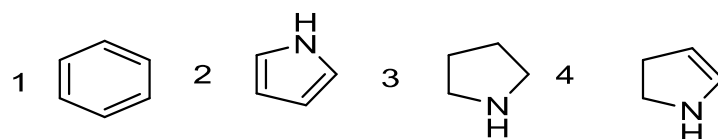
32. Circle represents most acidic hydrogen in this molecule. Which of the following is correct representation?



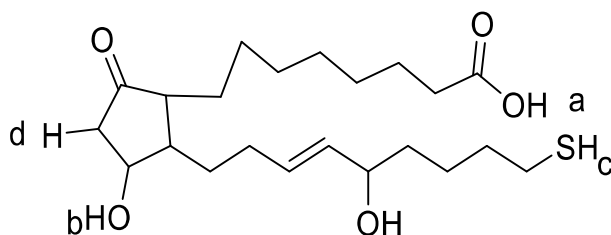
33. Find out the most acidic compound?



34. Among the following compounds, the most basic compound is:

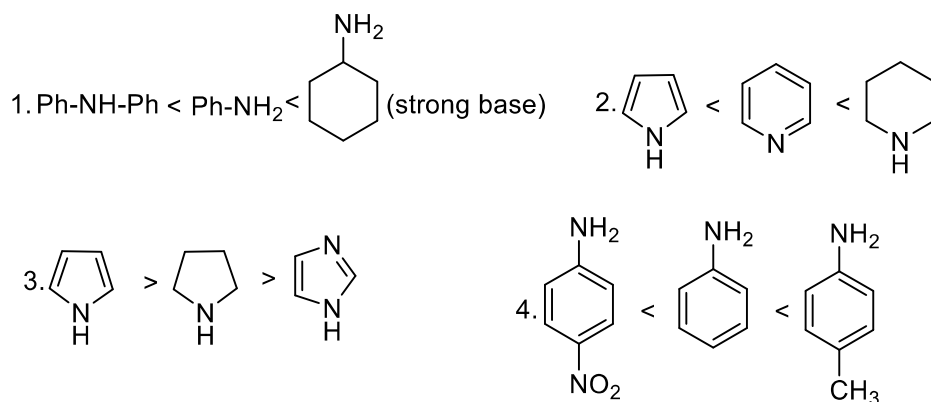


35. Identify most acidic hydrogen in given compound



- (1) a (2) b (3) c (4) d

36. In sets a – d, only one of the set is incorrect regarding basic strength select it:



37. What is the decreasing order of strength of the bases?

OH^- , NH_2^- , $\text{H}-\text{C}\equiv\text{C}^-$ and $\text{CH}_3-\text{CH}_2^-$

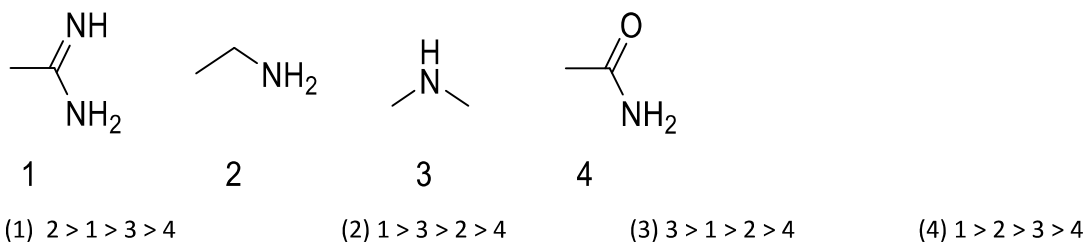
(1) $\text{CH}_3-\text{CH}_2^- > \text{NH}_2^- > \text{H}-\text{C}\equiv\text{C}^- > \text{OH}^-$

(2) $\text{H}-\text{C}\equiv\text{C}^- > \text{CH}_3-\text{CH}_2^- > \text{NH}_2^- > \text{OH}^-$

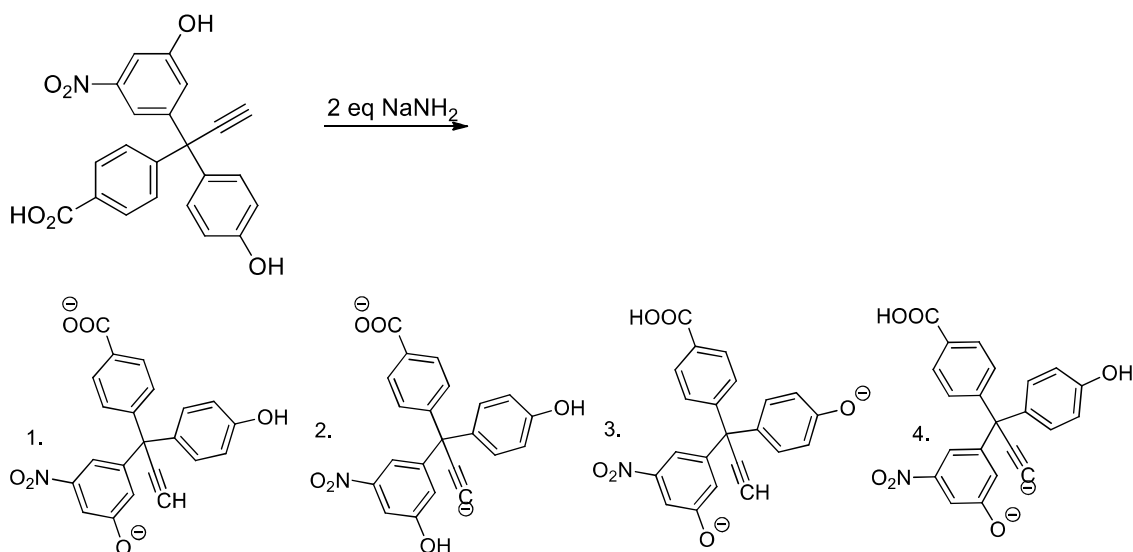
(3) $\text{OH}^- > \text{NH}_2^- > \text{H}-\text{C}\equiv\text{C}^- > \text{CH}_3-\text{CH}_2^-$

(4) $\text{NH}_2^- > \text{H}-\text{C}\equiv\text{C}^- > \text{OH}^- > \text{CH}_3-\text{CH}_2^-$

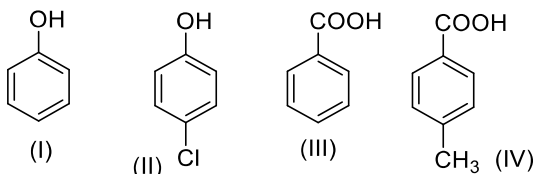
38. The correct order of basicities of the following compounds is



39. The product A will be

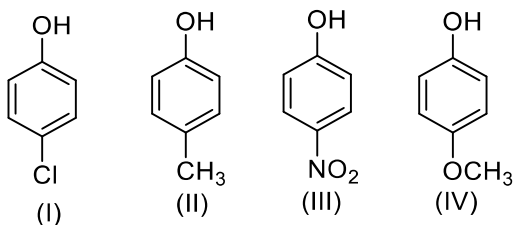


40. The correct acidity order of the following is



- (1) $3 > 4 > 2 > 1$ (2) $4 > 3 > 1 > 2$ (3) $3 > 2 > 1 > 4$ (4) $2 > 3 > 4 > 1$

41. Arrange the following compounds in the order of decreasing acidity



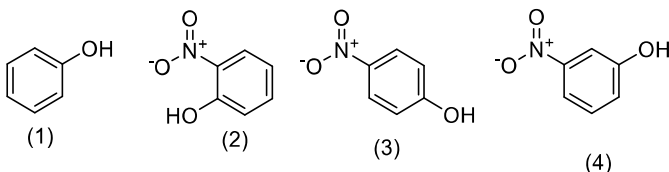
- (1) $2 > 4 > 1 > 3$ (2) $1 > 2 > 3 > 4$ (3) $3 > 1 > 2 > 4$ (4) $4 > 3 > 1 > 2$

42. Arrange the following in the decreasing order of acidity of the hydrogen indicated in *italic*

1. CH_3COCH_3 2. $\text{CH}_3\text{COCH}_2\text{COCH}_3$ 3. $\text{CH}_3\text{OOCCH}_2\text{COOCH}_3$ 4. $\text{CH}_3\text{COCH}_2\text{NO}_2$

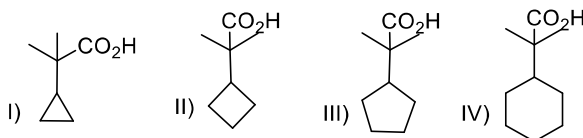
- (1) (ii) > (iii) > (i) > (iv) (2) (iv) > (ii) > (iii) > (i) (3) (iv) > (iii) > (ii) > (i) (4) (ii) > (iv) > (iii) > (i)

43. The correct order of the K_a values for the conjugate acid's compounds given below is



- (1) $2 > 3 > 1 > 4$ (2) $4 > 2 > 3 > 1$ (3) $3 > 2 > 4 > 1$ (4) $3 > 4 > 2 > 1$

44. Arrange the following in decreasing order of their acidity?

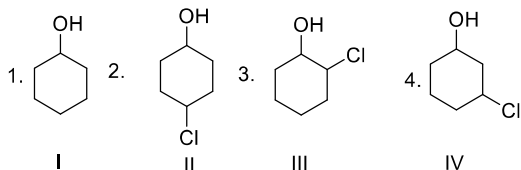


- (1) $I > II > III > IV$ (2) $IV > III > II > I$ (3) $I > III > IV > II$ (4) $II > III > IV > I$

45. The acidity in decreasing order of different acids is

- (1) formic acid > chloroacetic acid > acetic acid > propanoic acid
 (2) formic acid > propanoic acid > chloroacetic acid > acetic acid
 (3) chloroacetic acid > acetic acid > formic acid > propanoic acid
 (4) chloroacetic acid > formic acid > acetic acid > propanoic acid

46. Rank the following alcohols in order of increasing acidity.

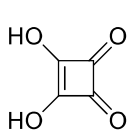


- (1) $1 < 2 < 3 < 4$ (2) $1 < 2 < 4 < 3$ (3) $1 < 3 < 4 < 2$ (4) $4 < 1 < 3 < 2$

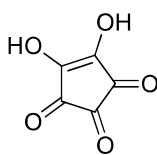
47. Which of the following has the most stable conjugate acid?

- (1) $(\text{CH}_3)_2\text{NH}$ (2) $(\text{CH}_3)_3\text{N}$ (3) $\text{C}_6\text{H}_5\text{NH}_2$ (4) $\text{C}_6\text{H}_5\text{NHCH}_3$

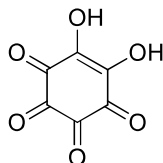
48. The acidity of the protons H in each of the following is



(i)



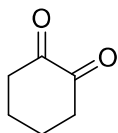
(ii)



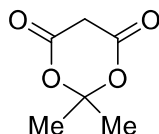
(iii)

- (1) $i > ii > iii$ (2) $iii > ii > i$ (3) $i > iii > ii$ (4) $iii > i > ii$

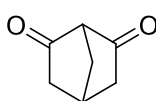
49. Arrange the given carbon acids in the increasing order of acidic strength.



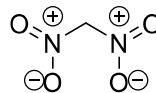
A



B



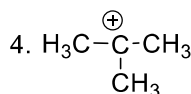
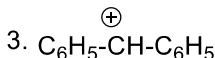
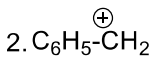
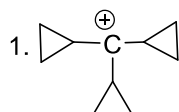
C



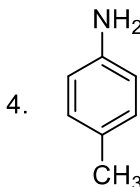
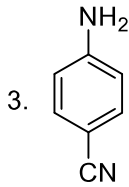
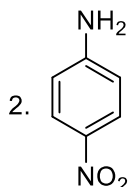
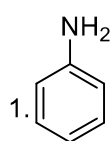
D

- (1) $A < B < D < C$ (2) $D < C < B < A$ (3) $C < B < D < A$ (4) $C < A < B < D$

50. Which among the following carbocations is most stable?



51. Consider the following compounds:



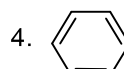
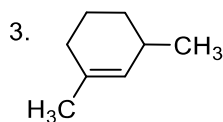
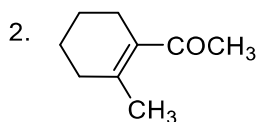
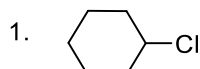
Arrange these compounds in decreasing order of their basicity:

- (1) $1 > 2 > 3 > 4$ (2) $4 > 1 > 3 > 2$ (3) $2 > 3 > 4 > 1$ (4) $1 > 3 > 2 > 4$

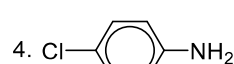
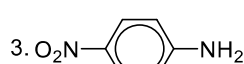
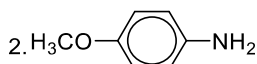
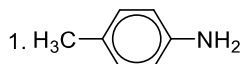
52. Which one of the nitrogen containing compounds is an electrophile?

- (1) $\text{NH}_2 - \text{NH}_2$ (2) $\text{NH}_2 - \text{OH}$ (3) NF_3 (4) NH_3

53. In which of the following molecules all the effects namely inductive, mesomeric and hyperconjugation operate



54. Arrange the given compounds in decreasing order of basicity: Select the correct answer from the codes given below:



- (1) $4 > 2 > 1 > 3$ (2) $2 > 1 > 4 > 3$ (3) $2 > 1 > 3 > 4$ (4) $1 > 2 > 4 > 3$

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CSIR NET, GATE, TIFR Exam Questions

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Section II

Model Practice Questions

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Questions From Exams

Section I

- 1 Chemical Periodicity
 - 2 Chemical Bonding
 - 3 Main Group Elements
 - 4 Coordination Chemistry
 - 5 Inner Transitions Elements
 - 6 Organometallic Chemistry
 - 7 Bioinorganic Chemistry
 - 8 Inorganic Spectroscopy
 - 9 Acid and Base Chemistry
 - 10 Nuclear Chemistry
 - 11 Analytical Chemistry
-

Previous Year Questions- CSIR NET

PART-B

[CSIR NET JUNE-2018]

1. Among the elements Zn, Ga, Ge and As, the one with the lowest first ionization energy is

- (1) As (2) Zn
(3) Ga (4) Ge

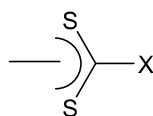
[CSIR NET DEC-2017]

2. The first ionization energy is the lowest for:

- (1) Br (2) Se
(3) P (4) As

[CSIR NET JUNE -2017]

3. Consider the following sulfur donor atom bearing bidentate ligand where X and name of ligands are given in following columns:



X	Ligand name
A. NR ₂	I. dithiocarbonate
B. OR	II. dithiocarbamate
C. O ⁻	III. xanthate
D. SR	IV. Thioxanthate

Correct match of entries given in two columns is

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

[CSIR NET JUNE-2013]

4. Which of the following pairs has the highest difference in their first ionization energy?

- (1) Xe, Cs (2) Kr, Rb
(3) Ar, K (4) Ne, Na

[CSIR NET DEC-2012]

5. The electronegativity differences is the highest for the pair?

- (1) Li, Cl (2) K, F
(3) Na, Cl (4) Li, F

[CSIR NET JUNE-2012]

6. The size of the d orbitals in Si, P, S and Cl follows the order.

- (1) Cl > S > P > Si (2) Cl > P > S > S
(3) P > S > Si > Cl (4) Si > P > S > Cl

[CSIR NET DEC-2011]

7. Among the following pairs?

- A. oxygen-sulfur
B. nitrogen -phosphorus
C. phosphorus arsenic
D. chlorine- iodine

Those in which the first ionization energies differ by more than 300kJ mole⁻¹ are:

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

PART-C

[CSIR NET JUNE-2018]

8. Identify the correct statements about the electronegativity of groups given below:

- (A) CF₃ group has greater value than that of NF₂
(B) NH₂ group has lower value than that of NF₂
(C) OH group has greater value than that of NF₂
(D) CH₃ and C₂H₅ groups have almost similar values

Correct answer is?

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

[CSIR NET DEC-2017]

9. Allred-Rochow electronegativity of an element is:

- A. directly proportional to the effective nuclear charge
B. directly proportional to the covalent radius
C. inversely proportional to the square of the covalent radius
D. directly proportional to the square of the effective nuclear charge

The correct answer is:

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

[CSIR NET JUNE-2014]

10. The correct order of the size of S, S²⁻, S²⁺ and S⁴⁺ species is:

- (1) S > S²⁺ > S⁴⁺ > S²⁻ (2) S²⁺ > S⁴⁺ > S²⁻ > S
(3) S²⁻ > S > S²⁺ > S⁴⁺ (4) S⁴⁺ > S²⁻ > S > S²⁺

[CSIR NET JUNE-2014]

11. The correct order of decreasing electronegativity of the following atoms is:

- (1) $\text{As} > \text{Al} > \text{Ca} > \text{S}$ (2) $\text{S} > \text{As} > \text{Al} > \text{Ca}$
 (3) $\text{Al} > \text{Ca} > \text{S} > \text{As}$ (4) $\text{S} > \text{Ca} > \text{As} > \text{Al}$

[CSIR NET JUNE-2013]

12. Identify the pairs in which the covalent radii of elements are almost similar:

- (A) Nb, Ta (B) Mo, W
 (C) La, Lu (D) Sc, Y
 (1) A and B only (2) A and C only
 (3) B and C only (4) A, B and C only

[CSIR NET DEC-2019]

13. The correct order of solubility of silver halides in liquid ammonia is

- (1) $\text{AgF} < \text{AgCl} < \text{AgBr} < \text{AgI}$ (2) $\text{AgCl} < \text{AgI} < \text{AgBr} < \text{AgF}$
 (3) $\text{AgI} < \text{AgCl} < \text{AgF} < \text{AgBr}$ (4) $\text{AgI} < \text{AgBr} < \text{AgCl} < \text{AgF}$

[CSIR NET DEC-2020 PONDYCHERRY]

14. The first ionization energy of the metals follows the order

- (1) $\text{Zn} > \text{Cd} > \text{Hg}$ (2) $\text{Hg} > \text{Zn} > \text{Cd}$
 (3) $\text{Hg} > \text{Cd} > \text{Zn}$ (4) $\text{Cd} > \text{Zn} > \text{Hg}$

ANSWERS:

1	2	3	4	5	6	7	8	9	10
3	2	1	4	2	4	2	4	2	3
11	12	13	14						
2	1	1	2						

Previous Year Questions- CSIR NET

A. VSEPR Theory

PART-B

[CSIR NET DEC-2017]

1. Among ClO_3^- , XeO_3 and SO_3 , species with pyramidal shape is/are?

- (1) ClO_3^- and XeO_3 (2) XeO_3 and SO_3
(3) ClO_3^- and SO_3 (4) SO_3

[CSIR NET DEC-2017]

2. Geometries of SnF_3 and XeF_2O_2 , respectively, are?

- (1) square planar and square planar
(2) tetrahedral and tetrahedral
(3) square planar and trigonal bipyramidal
(4) tetrahedral and trigonal bipyramidal

[CSIR NET JUNE-2017]

3. Based on VSEPR theory, the predicted shapes of $[\text{XeF}_5]^-$ and BrF_5 , respectively, are:

- (1) pentagonal planar and square pyramidal
(2) square pyramidal and trigonal bipyramidal
(3) trigonal bipyramidal and square pyramidal
(4) square pyramidal and pentagonal planar

[CSIR NET DEC-2016]

4. The expected H-H-H bond angle in $[\text{H}_3]^+$ is:

- (1) 180° (2) 120°
(3) 60° (4) 90°

[CSIR NET JUNE-2016]

5. The correct shape of $[\text{TeF}_5]^-$ ion on the basis of VSEPR theory is:

- (1) Trigonal bipyramidal (2) Square pyramidal
(3) Pentagonal planar (4) See-saw

[CSIR NET DEC-2015]

6. The structures of XeF_2 and XeO_2F_2 respectively are:

- (1) bent, tetrahedral (2) linear, square planar
(3) linear, see-saw (4) bent, see-saw

[CSIR NET JUNE-2014]

7. The correct non-linear and iso-structural pair is:

- (1) SCL_2 and I_3^- (2) SCL_2 and I_3^+
(3) SCL_2 and ClF_2^- (4) I_3^+ and ClF_2^-

[CSIR NET JUNE-2014]

8. Structures of SbPh_5 and PPh_5 respectively are:

- (1) trigonal bipyramidal, square pyramidal
(2) square pyramidal, trigonal bipyramidal
(3) trigonal bipyramidal, trigonal bipyramidal
(4) square pyramidal, square pyramidal

[CSIR NET DEC-2013]

9. According to VSEPR theory, the geometry (with lone pair) around the central iodine in I_3^+ and I_3^- ions respectively are:

- (1) tetrahedral and tetrahedral
(2) trigonal bipyramidal and trigonal bipyramidal
(3) tetrahedral and trigonal bipyramidal
(4) tetrahedral and octahedral

[CSIR NET DEC-2012]

10. Which ones among CO_3^{2-} , SO_3 , XeO_3 and NO_3^- – have planar structure?

- (1) CO_3^{2-} , SO_3 , XeO_3 (2) SO_3 , XeO_3 and NO_3^-
(3) CO_3^{2-} , XeO_3 and NO_3^- (4) CO_3^{2-} , SO_3 and NO_3^-

[CSIR NET JUNE-2012]

11. The total number of lone pairs of electrons in I_3^- is:

- (1) Zero (2) Three
(3) Six (4) Nine

[CSIR NET JUNE-2011]

12. Among SF_4 , BF_4^- and ICl_4^- the number of species having two lone pair of electrons on the central atom according to VSEPR theory is:

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

[CSIR NET JUNE-2011]

13. In the molecule's H_2O , NH_3 and CH_4 :

- (1) The bond angles are same
(2) The bond distances are same.
(3) The hybridizations are same
(4) The shapes are same.

[CSIR NET DEC-2018]

14. Among SiCl_4 , $\text{P}(\text{O})\text{CH}_3$, NF_3 , $\text{trans-}[\text{SnCl}_4(\text{py})_2]$ (py = pyridine), those with zero dipole moment are
- (1) SiCl_4 and NF_3
 - (2) SiCl_4 , $\text{P}(\text{O})\text{Cl}_3$ and $\text{trans-SnCl}_4(\text{py})_4$
 - (3) SiCl_4 and $\text{trans-SnCl}_4(\text{py})_2$
 - (4) NF_3 and $\text{trans-SnCl}_4(\text{py})_2$

[CSIR NET DEC-2020]

15. The magnitude of bond angles in gaseous NF_3 , SbF_3 and SbCl_3 follow the order
- (1) $\text{NF}_3 > \text{SbF}_3 > \text{SbCl}_3$
 - (2) $\text{SbCl}_3 > \text{SbF}_3 > \text{NF}_3$
 - (3) $\text{SbF}_3 > \text{SbCl}_3 > \text{NF}_3$
 - (4) $\text{NF}_3 > \text{SbCl}_3 > \text{SbF}_3$

ANSWERS

1	2	3	4	5	6	7	8	9	10
1	4	1	3	2	3	2	2	3	4
11	12	13	14	15					
4	1	3	3	4					

Part C

[CSIR NET DEC-2017]

1. According to Bent's rule, for *p*-block elements, the correct combination of geometry around the central atom and position of more electro-negative substituent is:
- (1) Trigonal bipyramidal and axial
 - (2) Trigonal bipyramidal and equatorial
 - (3) Square pyramidal and axial
 - (4) Square pyramidal and basal

[CSIR NET JUNE-2016]

2. Choose the correct option for carbonyl fluoride with respect to bond angle and bond length.
- (1) $\angle \text{F-C-F} > \angle \text{F-C-O}$ and $\text{C-F} > \text{C-O}$
 - (2) $\angle \text{F-C-F} > \angle \text{F-C-O}$ and $\text{C-F} < \text{C-O}$
 - (3) $\angle \text{F-C-F} < \angle \text{F-C-O}$ and $\text{C-F} > \text{C-O}$
 - (4) $\angle \text{F-C-F} < \angle \text{F-C-O}$ and $\text{C-F} < \text{C-O}$

[CSIR NET DEC-2015]

3. The number of lone pair(s) of electrons on the central atom in $[\text{BrF}_4]^-$, XeF_6 and $[\text{SbCl}_6]^{3-}$ are, respectively:
- (1) 2, 0 and 1
 - (2) 1, 0 and 0
 - (3) 2, 1 and 1
 - (4) 2, 1 and 0

[CSIR NET JUNE-2015]

4. The geometries of $[\text{Br}_3]^+$ and $[\text{I}_5]^+$, respectively, are:
- (1) trigonal and tetrahedral
 - (2) tetrahedral and trigonal bipyramidal
 - (3) tetrahedral and tetrahedral
 - (4) linear and trigonal pyramidal

[CSIR NET JUNE-2013]

5. The number of lone-pairs are identical in the pairs:
- (1) XeF_4 , ClF_3
 - (2) XeO_4 , ICl_4^-
 - (3) XeO_2F_2 , ICl_4^-
 - (4) XeO_4 , ClF_3

[CSIR NET DEC-2012]

6. In the solid state, the CuCl_5^{3-} ion has two types of bonds. These are:
- (1) Three long and two short
 - (2) Two long and three short
 - (3) One long and four short
 - (4) Four long and one short

[CSIR NET JUNE-2012]

7. The DECREASING order of dipole moment of molecules is:
- (1) $\text{NF}_3 > \text{NH}_3 > \text{H}_2\text{O}$
 - (2) $\text{NH}_3 > \text{NF}_3 > \text{H}_2\text{O}$
 - (3) $\text{H}_2\text{O} > \text{NH}_3 > \text{NF}_3$
 - (4) $\text{H}_2\text{O} > \text{NF}_3 > \text{NH}_3$

[CSIR NET DEC-2011]

8. Match list I (compounds) with list II (structures), and select the correct answer using the codes given below.

List-I

- (A) XeO_4
(B) BrF_4^-
(C) SeCl_4

List-II

- (i) square planar
(ii) tetrahedral
(iii) distorted tetrahedral

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

[CSIR NET DEC-2011]

9. Among the following pairs, those in which both species have similar structures are:
- (A) N_3^- , XeF_2
(B) $[\text{ICl}_4]^-$, $[\text{PtCl}_4]^{2-}$
(C) $[\text{ClF}_2]^+$, $[\text{ICl}]^-$
(D) XeO_3 , SO_3
- (1) (A) and (B) only
 - (2) (A) and (C) only
 - (3) (A), (B) and (C) only
 - (4) (B), (C) and (D) only

[CSIR NET JUNE-2011]

10. According to VSEPR theory, the molecule/ion having ideal tetrahedral shape is:
- (1) SF_4
 - (2) SO_4^{2-}
 - (3) S_2Cl_2
 - (4) SO_2Cl_2

[CSIR NET JUNE-2011]

11. The molecule with highest number of lone-pairs and has a linear shape based on VSEPR theory is:

- (1) CO_2 (2) I_3^-
(3) NO_2^- (4) NO_2^+

ANSWERS									
1	2	3	4	5	6	7	8	9	10
1	3	3	2	1	1	3	3	3	2
11									
2									

B. Molecular Orbital Theory

Part B:

[CSIR NET JUNE 2018]

1. Removal of an electron from NO molecule results in
- an increase in the $\nu(\text{NO})$ in the IR spectrum
 - an EPR active species
 - electrons in HOMOs being closer to the oxygen than to nitrogen 2p orbitals. electrons in HOMOs being closer to the nitrogen than to oxygen 2p orbitals

The correct answer is:

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

[CSIR NET DEC-2016]

2. The HOMO (highest occupied molecular orbital) to LUMO (lowest unoccupied molecular orbital) electronic transition responsible for the observed colours of halogen molecules (gas) is:

- (1) $\pi^* \rightarrow \sigma^*$ (2) $\pi \rightarrow \pi^*$
(3) $\sigma \rightarrow \sigma^*$ (4) $\pi \rightarrow \sigma^*$

[CSIR NET JUNE-2016]

3. Correct combination for π and π^* orbitals in B_2 molecule are:

	π	π^*
1	Gerade	Ungerade
2	Ungerade	Gerade
3	Gerade	Gerade
4	Ungerade	Ungerade

[CSIR NET DEC-2014]

4. Among F^- , Na^+ , O^{2-} and Mg^{2+} ions, those having the highest and the lowest ionic radii respectively are:

- (1) O^{2-} and Na^+ (2) F^- and Mg^{2+}
(3) O^{2-} and Mg^{2+} (4) Mg^{2+} and O^{2-}

[CSIR NET DEC-2013]

5. The reason for the chemical inertness of gaseous nitrogen at room temperature is best given by its:

- (1) high bonding energy only
(2) electronic configuration
(3) HOMO-LUMO gap only
(4) high bond energy and HOMO-LUMO gap

[CSIR NET DEC-2012]

6. When a hydrogen atom is placed in an electric field along the y-axis, the orbital that mixes most with the ground state 1s orbital is:

- (1) 2s (2) $2p_x$
(3) $2p_y$ (4) $2p_z$

[CSIR NET DEC-2011]

7. The number of antibonding electrons in NO and CO according to MO theory are respectively:

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

Part C:

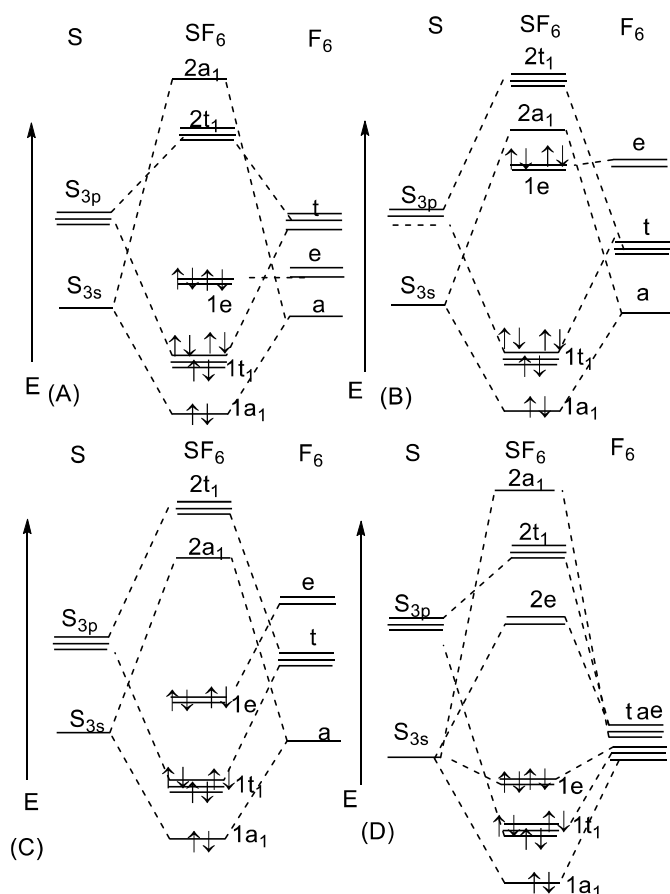
[CSIR NET DEC-2014]

8. The δ -bond is formed via the overlap of?

- (1) $d_{x^2-y^2}$ and d_{x^2y} orbitals
(2) d_{xz} and d_{yz} orbitals
(3) d_{xy} and d_{xy} orbitals
(4) d_{yz} and d_{yz} orbitals

[CSIR NET DEC-2014]

9. The correct schematic molecular energy diagram for SF_6 molecule is:



[CSIR NET JUNE-2011]

10. The highest occupied MO in N_2 and O_2^+ respectively are (take x-axis as internuclear axis):

- (1) $\sigma 2p_x, \pi^* 2p_y$ (2) $\pi 2p_y, \pi 2p_z$
 (3) $\sigma^* 2p_x, \sigma 2p_x$ (4) $\pi^* 2p_y, \pi^* 2p_z$

[CSIR NET DEC-2018]

11. The characters of LUMO of CN^- and O_2 respectively, are:

- (1) σ_g and π_u (2) π_u and σ_u
 (3) π_g and σ_u (4) σ_u and π_g

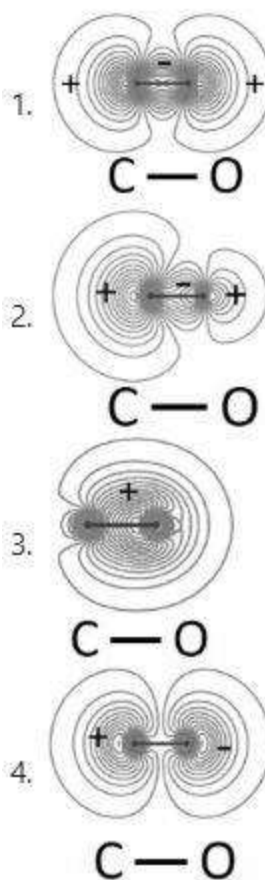
[CSIR NET DEC-2019 ASSAM SET]

12. The compound $[\text{OCNCO}]^- [\text{Sb}_3\text{F}_{16}]$ has C-N-C angle 131° and C-O bond length 112 pm. The Lewis structure consistent with this data has formal charge of

- (1) -1 on N (2) +1 on C
 (3) -1 on C (4) +1 on N

[CSIR NET DEC-2020 PONDYCHERRY SET]

13. For CO, the contour plot of the molecular orbital which best represents the HOMO is



ANSWERS:

1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	2	1	3	1	1
11	12	13							
3	1	2							

GATE Chemistry Previous Year Questions

[GATE-2000]

1. The compound $(\text{SiH}_3)_3\text{N}$ is expected to be
 (1) planar and more basic than $(\text{CH}_3)_3\text{N}$
 (2) pyramidal and less basic than $(\text{CH}_3)_3\text{N}$
 (3) planar and less basic than $(\text{CH}_3)_3\text{N}$
 (4) pyramidal and more basic than $(\text{CH}_3)_3\text{N}$

[GATE-2000]

2. Among the following diatomic molecules, the shortest bond length is to be found in
 (1) C_2 (2) N_2
 (3) O_2 (4) F_2

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PRACTICE QUESTIONS

Section I

1. Quantum Chemistry
 2. Group Theory
 3. Molecular Spectroscopy
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 5. Statistical Thermodynamics
 6. Electrochemistry
 7. Chemical Kinetics
 8. Colloidal and Surface Chemistry
 9. Solid State Chemistry
 10. Polymer Chemistry
-

Section 1:

Introduction to the fundamentals of quantum mechanics

- Which of the following statement is correct?
 - Only charged particle in motion are accompanied by matter waves
 - All particles in motion whether charged or uncharged are accompanied by matter wave
 - No particle whether rest or in motion is ever accompanied by matter waves
 - Only sub-atomic particles in motion are accompanied by matter waves
- Matter waves are
 - longitudinal
 - electromagnetic
 - always travel with the speed of light
 - show diffraction
- Which of the following was not concluded from Rutherford nuclear model of atom?
 - For a pure element, all the atoms are identical in mass, shape and size
 - Every atom consists of a heavily, positively charged, centre in which entire mass of atom is concentrated
 - Negatively charged electrons revolve in circular orbits around the nucleus
 - This was the first model of established to existence of nucleus
- A photon of wavelength 4000 Å strikes a metal surface, the work function of the metal being 2.13 eV. The kinetic energy of the emitted photoelectron is

(1) 0.97 eV	(2) 9.7 eV
(3) 5.23 eV	(4) 3.10 eV
- Electrons with momentum p are incident at an angle of 30° with the crystal surface. If d is the separation between crystal atomic planes parallel to the surface, what is the smallest value of p in terms of d and Planck's constant h , for which the reflected beam will show a maximum intensity?

(1) $2h/d$	(2) $h/(2d)$
(3) d/h	(4) h/d

- The de-Broglie wavelength of a particle having KE E_k is given by

(1) $\lambda = \frac{h}{\sqrt{E_k}}$	(2) $\lambda = \frac{h}{\sqrt{2mE_k}}$
(3) $\lambda = \frac{h}{\sqrt{mE_k}}$	(4) $\lambda = \frac{h}{\sqrt{3mE_k}}$

- The de-Broglie wavelength of a charge q and accelerated through a potential difference of V volts is

(1) $\lambda = \frac{h}{\sqrt{mqV}}$	(2) $\lambda = \frac{h}{\sqrt{qV}}$
(3) $\lambda = \frac{h}{\sqrt{2mqV}}$	(4) $\lambda = \frac{h}{mqV}$

- The de-Broglie hypothesis is associated with:
 - wave nature of electrons only
 - wave nature of protons only
 - wave nature of radiation
 - wave nature of all material particles
- Which one of the following is correct in respect of an electron and a proton having same de-Broglie wavelength of 2 Å ?
 - Both have same kinetic energy
 - The kinetic energy of proton is more than that of electron
 - Both have same velocity
 - Both have same momentum
- The size of an atomic nucleus is 10^{-14} m . What would be the uncertainty in speed (ms^{-1}) of an electron if it were to exist inside the nucleus? [$h = 6.625 \times 10^{-34} \text{ Js}^{-1}$, $m_e = 9.1 \times 10^{-31} \text{ kg}$]

(1) 5.27×10^{-21}	(2) 5.8×10^{-9}
(3) 5.8×10^9	(4) 1.725×10^{-10}

Section 2:

Postulates of the quantum mechanics and operators

- With symbols having the usual meaning, the wavelength of the electron of energy E is given by

(1) $2mhE$	(2) $\frac{2h}{mE}$
(3) $\frac{1}{\sqrt{2mE}}$	(4) $\frac{2\sqrt{2mE}}{h}$
- The wave function for a particle moving in x -direction $\psi(x) = e^{-Lx}$, $0 < x < \infty$, the value of normalization constant A is

(1) $\frac{1}{\sqrt{2L}}$	(2) $\frac{1}{\sqrt{L}}$
(3) $L^{3/2}$	(4) $\frac{1}{L^{3/2}}$

3. For the wave function $\psi(x) = N\pi x$, $0 < x < \sigma$, the value of N is
 (1) $\frac{1}{\pi\sigma^2}$ (2) $\pi\sigma^2$
 (3) $\frac{2}{\sqrt{\pi^2\sigma^2}}$ (4) $\sqrt{\pi\sigma^2}$
4. If $\phi = A e^{im\phi}$, then value of A after normalization is ($0 \leq \phi \leq 2\pi$)
 (1) $\frac{1}{\sqrt{\pi}}$ (2) $\frac{1}{\sqrt{2\pi}}$
 (3) $\frac{1}{\sqrt{3\pi}}$ (4) $\frac{2}{\sqrt{\pi}}$
5. A particle is described by a wavefunction $\psi(x) = e^{-|x|}$ in one-dimension. What is the probability that it will be found in the region $|x| \leq a$, $a > 0$?
 (1) e^{-a} (2) e^{-2a}
 (3) $1 - e^{-a}$ (4) $1 - e^{-2a}$
6. The wave function of a particle is given by $\Psi = C \exp(-x^2/\sigma^2)$, $-\infty < x < \infty$, where C and σ are constants. The probability of finding the particle in the region $0 < x < \infty$
 (1) 1 (2) $1/3$
 (3) $1/2$ (4) $1/4$
7. A particle is described by a wave function $\psi(x) = e^{-|x|}$ in one-dimension. What is the probability that it will be found in the region $|x| \leq a$, $a > 0$?
 (1) e^{-a} (2) e^{-2a}
 (3) $1 - e^{-a}$ (4) $1 - e^{-2a}$
8. The expectation value of momentum of a particle whose normalised wave function is $\psi(x) = N e^{\left(-\frac{x^2}{2a^2} + ikx\right)}$
 (1) 0 (2) $\frac{hk}{2}$
 (3) $hk/2\pi$ (4) h^2k^2
9. Which of the following is an allowed wave function for a particle in a bound state? N is a constant and $\alpha, \beta > 0$
 (1) $\Psi = \frac{N e^{-\alpha r}}{r^3}$
 (2) $\Psi = N(1 - e^{-\alpha r})$
 (3) $\psi = N e^{-\beta(x^2+y^2+z^2)}$
 (4) $\psi = \{\text{non zero constant if } r < R \text{ 0 if } r > R\}$
10. The probability of finding the particle in a volume dV can be written as
 (1) $P(r, t) dV = |\psi(r, t)| dV$
 (2) $P(r, t) = |\psi(r, t)| dV$
 (3) $P(r, t) dV = |\psi(r, t)|^2 dV$
 (4) $P(r, t) = |\psi(r, t)|^3 dV$
11. If the probability that x lies between x and x + dx is $p(x)dx = a e^{-ax} dx$, where $a < x < \infty$, $a > 0$, then the probability that x lies between x_1 and x_2 ($x_2 > x_1$) is
 (1) $a(e^{-ax_1} - e^{-ax_2})$ (2) $a^2(e^{-ax_1} - e^{-ax_2})$
 (3) $e^{-ax_2}(e^{-ax_1} - e^{-ax_2})$ (4) $e^{-ax_1}(e^{-ax_1} - e^{-ax_2})$
12. According to Schrodinger, a particle is equivalent to a
 (1) wave packet (2) single wave
 (3) light wave (4) None of these
13. The Schrodinger time independent equation can be written as
 (1) $H\psi = E\psi$ (2) $H\psi = (E - V)\psi$
 (3) $H\psi = (E + V)\psi$ (4) $H\psi + E\psi = 0$
14. Which of the following wave functions can be solutions of Schrodinger's equation for all values of x ($x > 0$)?
 (1) $\Psi = A \sec x$ (2) $\Psi = A \tan x$
 (3) $\Psi = A e^{x^2}$ (4) $\Psi = A e^{-x^2}$
15. The time independent Schrodinger's equation of a system represents the conservation of the
 (1) total binding energy of the system
 (2) total potential energy of the system
 (3) total kinetic energy of the system
 (4) total energy of the system
16. The operators $S_{\pm}$ are defined by, $S_{\pm} = S_x \pm iS_y$ where S_x, S_y are components of the spin angular momentum operator. The commutator $[S_z, S_{\pm}]$ is:
 (1) $\hbar S_{\pm}$ (2) $\hbar S_{\pm}$
 (3) $-\hbar S_{\pm}$ (4) $-\hbar S_{\pm}$
17. Why are operators important in the study of quantum mechanics?
 (1) To find the energy values of a system
 (2) Schrodinger used operators in the derivation of his equation.
 (3) Applying an operator to a wavefunction reveals some information about the particle it describes.
 (4) Operators are used in solving the Schrodinger equation to find wavefunctions.
18. The operators x and d/dx will commute when operating on which of the following functions?
 (1) 0 (2) $x e^x$
 (3) 1 (4) $\sin(x)$

19. A fundamental assumption of quantum mechanics is:
- That anything can be measured
 - That the value of an observable is always strictly defined
 - That every observable can be represented by a linear Hermitian operator
 - That everything is an observable
20. The expectation value is the _____ of the observable:
- uncertainty
 - variance
 - most probable value
 - mean value
21. Which of the following functions are eigenstates of position?
- $\cos(ax)$
 - e^{ix}
 - x
 - None of the above
22. Choose the correct statement:
- Hermitian operators can have complex eigenvalues
 - A Hermitian operator must be real
 - All observables can be represented by a Hermitian operator
 - All Hermitian operators represent observables
23. Two operators A and B are said to commute if:
- $[A, B] > 0$
 - $[A, B] = 0$
 - $[A, B] < 0$
 - $[A, B] = 1$
24. Two observables can only be measured precisely and simultaneously if:
- The commutator of their operators is nonzero
 - The result of the measurement is divided by the commutator of their operators
 - Their corresponding operators are compatible
 - They are not position and momentum
25. The commutator of $\hat{x}^2$ and $\hat{p}_x$ is
- zero
 - $2i\hbar$
 - $2i\hbar\hat{p}_x$
 - $i\hbar\hat{p}_x^2$
26. The linear momentum operator $\hat{p}_x$ commutes with which of the following operators?
- $\hat{x}$
 - $\hat{z}$
 - $\hat{L}_y$
 - None of these
27. For a Gaussian wave packet described by $\psi(x) = A \exp(-\frac{x^2}{a^2})$, the value of momentum operator is
- 0
 - +a
 - a
 - undefine
28. The quantum mechanical operator for the momentum of a particle moving in one dimension given by
- $i\hbar \frac{\partial}{\partial x}$
 - $-i\hbar \frac{\partial}{\partial x}$
 - $i\hbar \frac{\partial}{\partial t}$
 - $-\frac{\hbar^2}{2m} \frac{\partial^2}{\partial x^2}$
29. In quantum mechanics a classical dynamical quantity is replaced by the corresponding quantum mechanical operator. Accordingly, the x-component of momentum, p_x is replaced by
- $\frac{\hbar}{2\pi} \cdot \frac{\partial}{\partial x}$
 - $\frac{i\hbar}{2\pi} \cdot \frac{\partial}{\partial y}$
 - $\hbar^2 \cdot \frac{\partial^2}{\partial x^2}$
 - $\frac{i\hbar}{2\pi} \cdot \frac{\partial}{\partial x}$
30. Which of the functions given below represents the bound state eigen function of the operator $-\frac{d^2}{dx^2}$ in the region $0 \leq x \leq \infty$ with eigenvalue -4?
- $A_0 e^{2x}$
 - $A_0 \cosh 2x$
 - $A_0 e^{-2x}$
 - $A_0 \sinh 2x$
31. Consider the following statements. In order that measurable properties (such as energy, linear momentum, etc.) of a quantum mechanical system be physically acceptable, it is essential that
- the corresponding eigen function $\psi(x)$ and its derivative $\frac{d\psi(x)}{dx}$ must be single valued for all dx values of x.
 - $\psi(x)$ and $\frac{d\psi(x)}{dx}$ must be continuous for all the dx values of x.
 - $\psi(x)$ must have a finite value over the space d l that the electron can occupy.
- Which of the statements given above are correct?
- I, II and III
 - I and II
 - I and III
 - II and III
32. The bound state eigenfunctions of an attractive finite range smooth potential, behave for larger r as
- $\exp(-\frac{r}{r_0})$, where r_0 is positive constant
 - $\frac{1}{r^n}$ $n > 0$
 - Constant
 - $\frac{\exp(ikr)}{r}$
33. For a particle described by the wavefunction $\psi = A(x + iy)e^{-r^2}$, where $r^2 = x^2 + y^2 + z^2$, the z- component of the angular momentum is ($\hbar = h/2\pi$, h = Planck's constant)
- zero
 - $\hbar$
 - $2\hbar$
 - $\hbar^2$

34. For what value of g is the function $x + gy$, an eigenfunction of L_z with eigen value $-\hbar$, where $\hbar = \frac{h}{2\pi}$ h being the Planck's constant?

(1) $g = 1$ (2) $g = -1$
 (3) $g = i$ (4) $g = -i$

Section 3:

Free Particle and a Particle in a box

1. For a particle in a one D box with infinite walls at $x=0$ and $x=L$, in the $n = 3$ state, the probability for finding the electron in the range $0 < x < L/4$ is:

(1) Greater than $1/3$
 (2) exactly $1/6$
 (3) Exactly $1/3$
 (4) none of the above is correct

2. The wave function of a particle in a box of length ' L ' is $\Psi(x) = \sqrt{\frac{2}{L}} \sin \frac{\pi x}{L}$, $0 < x < L$ $\Psi(x) = 0$, $x < 0$ and $x > L$

The probability of the particle finding in the region $0 < x < \frac{L}{2}$ is

(1) 0.4 (2) 0.3
 (3) 0.2 (4) 0.5

3. Degeneracy of a particle in the first excited state of a 3D box with infinite potential barriers is

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

4. Number of unpaired electrons if 10 electrons are placed in a 2D box with infinite potential barriers is

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

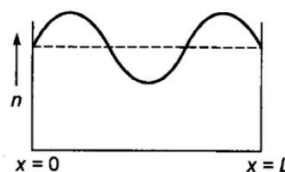
5. The average value of the linear momentum $\langle \hat{p}_x \rangle$ for a particle in the ground state of a 1D box is

(1) $\frac{h^2}{8ma^2}$ (2) 0
 (3) $\frac{h^2}{4ma^2}$ (4) $\frac{\pi^2 h^2}{ma^2}$

6. A particle of mass m is confined in the ground state of a one-dimensional box extending from $x = -2L$ to $x = +2L$. The wave function of the particle in this state is $\psi(r) = \psi_0 \cos \frac{\pi x}{4L}$, where ψ_0 is constant. The energy of eigen value corresponding to this state is

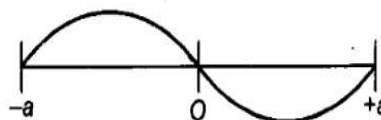
(1) $\frac{h^2 \pi^2}{2mL^2}$ (2) $\frac{h^2 \pi^2}{4mL^2}$
 (3) $\frac{h^2 \pi^2}{16mL^2}$ (4) $\frac{h^2 \pi^2}{32mL^2}$

7. The below figure shows the plot of the wave function n for an electron confined in a box, from $x = 0$ to $x = L$. The quantum number n of the above state n is



(1) 2 (2) 1
 (3) 5 (4) 3

8. A particle is confined in one-dimensional box with impenetrable walls at $x = \pm a$. Its energy eigen values is 2 eV and corresponding eigen function is shown below



the lowest possible energy of the particle is

(1) 4 eV (2) 2 eV
 (3) 1 eV (4) 0.5 eV

9. Consider a particle in one-dimensional box between $x = 0$ and $x = a$

$$V(x) = 0 \quad \text{for } 0 < x < a$$

$$= \infty \quad \text{for } x \leq 0 \text{ or } x \geq a$$

When it is in the ground state, what is the probability that it will be found in the region $(a/4) < x < (3a/4)$?

(1) $1/2$ (2) $(1/2) + (1/\pi)$
 (3) $(1/4) + (2/\pi)$ (4) $(1/4) + (1/\pi)$

10. For a particle of mass m in a one-dimensional box of length l ; what is the average of momentum p_x for the ground state?

(1) zero (2) $h/(2l)$
 (3) h/l (4) $h/(2\pi l)$

11. An electron of mass ' m ' is confined to a one dimensional box of length $2b$. It makes a radiative transition from 3rd excited state to ground state then, the frequency of transition

(1) $15/32mb^2$ (2) $15h/9mb^2$
 (3) $h/32mb^2$ (4) $h/8mb^2$

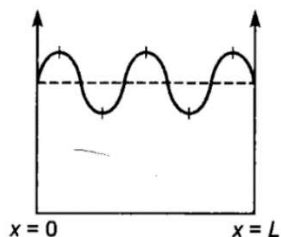
12. The quantum-mechanical probability of finding the particle in a one-dimensional 'box' in the middle third of the 'box' for first excited state is:

(1) 0.20 (2) 0.40
 (3) 0.66 (4) 0.33

13. A particle is placed in a one-dimensional box of size L along x -axis, ($0 < x < L$). Which of the following is true?

- (1) In the ground state, the probability of finding the particle in the interval $(\frac{L}{4}, \frac{3L}{4})$ is half
- (2) In the first excited state, the probability of finding the particle in the interval $(\frac{L}{4}, \frac{3L}{4})$ is half. This also holds for states with $n = 4, 6, 8, \dots$
- (3) For an arbitrary state, the probability of finding the particle in the left half of the well is half
- (4) In the ground state, the particle has definite momentum.

14. The given figure shows the plot of the wave function ψ_n for an electron confined in a box from $x=0$ to $x=L$, the quantum number of the above state ψ_n is



- (1) 3
 - (2) 4
 - (3) 5
 - (4) 6
15. Consider 8 electrons in a one-dimensional box of length a extending from $x = 0$ to $x = a$. What is the minimum allowed total energy using Pauli's exclusion principle for the system? (m = mass of electron)
- (1) $\frac{10h^2}{ma^2}$
 - (2) $\frac{8h^2}{ma^2}$
 - (3) $\frac{15h^2}{4ma^2}$
 - (4) $\frac{15h^2}{2ma^2}$
16. Consider a particle in one-dimensional box between $x=0$ and $x=a$
- $$V(x) = \begin{cases} = 0 & \text{for } 0 < x < a \\ = \infty & \text{for } x \leq 0 \text{ or } x \geq a \end{cases}$$
- When it is in ground state what is the probability that it will be found in the region $\frac{a}{4} < x < \frac{3a}{4}$?
- (1) $\frac{1}{2}$
 - (2) $\frac{1}{2} + \frac{1}{\pi}$
 - (3) $\frac{1}{4} + \frac{2}{\pi}$
 - (4) $\frac{1}{4} + \frac{1}{\pi}$
17. A particle of mass m is confined to a one-dimensional box extending from $x=0$ to $x=a$. Assuming the particle in the first excited state, what is the probability density at $x = \frac{a}{8}$?

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

18. The average value of P_x , for the box normalized wave function $\psi = \sqrt{\frac{2}{L}} \sin \frac{3\pi x}{L}$ is

- (1) $\frac{18\pi^2}{L}$
- (2) $\frac{6\pi}{L} - 1$
- (3) 0
- (4) $\frac{18\pi^2}{L^2}$

19. If ψ_{111} and ψ_{112} are the wave functions of the electrons in the two energy states 111 and 112 respectively in a cubical box of side a , then $\frac{\psi_{111}}{\psi_{112}}$ is

- (1) $\frac{\sin \frac{\pi x}{a}}{\sin \frac{2\pi x}{a}}$
- (2) $\frac{\sin \frac{2\pi x}{a}}{\sin \frac{\pi x}{a}}$
- (3) $\frac{\sin \frac{\pi x}{a}}{\sin \frac{\pi y}{a}}$
- (4) $\frac{\sin \frac{2\pi y}{a}}{\sin \frac{\pi y}{a}}$

Directions (Q. Nos. 20 and 21)

A particle is located in a three-dimensional cubic well of width L with impenetrable walls.

20. The sum of the energies of the third and the fourth levels is
- (1) $10\pi^2 h^2 / mL^2$
 - (2) $10\pi^2 h^2 / 3mL^2$
 - (3) $11\pi^2 h^2 / mL^2$
 - (4) $15\pi^2 h^2 / mL^2$
21. The degeneracy of the fourth level is given by
- (1) 1
 - (2) 2
 - (3) 3
 - (4) 4
22. If the wave function of a particle trapped in space between $x = 0$ and $x = L$ is given by $\psi(x) = A \sin [\frac{2\pi x}{L}]$, where A is a constant, for which value(s) of x will the probability of the finding of particle be maximum?
- (1) $\frac{L}{4}$
 - (2) $\frac{L}{2}$
 - (3) $\frac{L}{6}$ and $\frac{L}{3}$
 - (4) $\frac{L}{4}$ and $\frac{3L}{4}$
23. For a particle moving in x -direction and having a wave function $\Psi = A \sin(kx)$, its energy is
- (1) $\frac{k^2 h^2}{2m}$
 - (2) $\frac{kh}{2m}$
 - (3) $\frac{h^2 k^2}{m}$
 - (4) $m^2 h^2$
24. A free particle is moving in positive direction with a linear momentum p . The wave function of the particle normalized in a length L is
- (1) $\frac{1}{\sqrt{L}} \sin \frac{p}{h} x$
 - (2) $\frac{1}{\sqrt{L}} \cos \frac{p}{h} x$
 - (3) $\frac{1}{\sqrt{L}} e^{-ip/h x}$
 - (4) $\frac{1}{\sqrt{L}} e^{ip/h x}$

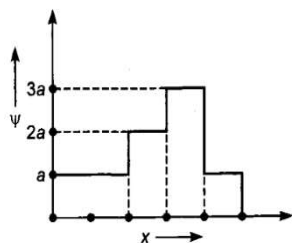
25. For wave function $\Psi(x) = 2L \sin \pi x/L$, $0 < x < L$, the expectation value of P^2 is

(1) $\frac{\pi^2 \hbar^2}{L^2}$ (2) $\frac{\pi^2 \hbar}{L^2}$
 (3) $\frac{\pi \hbar^2}{L^2}$ (4) $\frac{\pi^2 \hbar^2}{L^2}$

26. The wave function of a particle moving in a one-dimensional time independent potential $V(x)$ is given by $\Psi(x) = e^{-iax + b}$, where a and b are constants. This means that the potential $V(x)$ is of the form

(1) $V(x) \propto x$ (2) $V(x) \propto x^2$
 (3) $V(x) = 0$ (4) $V(x) \propto e^{-ax}$

27. The wave function for a particle constrained to move in one dimension is shown in the graph above ($\psi = 0$ for $x \leq 0$ and $x \geq 5$). What is the probability that the particle would be found between $x = 2$ and $x = 4$?

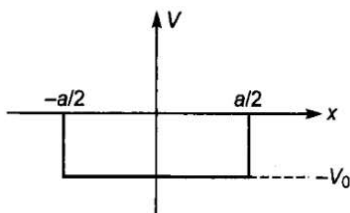


(1) $\frac{17}{64}$ (2) $\frac{25}{64}$
 (3) $\frac{5}{8}$ (4) $\frac{13}{16}$

28. The wave function for a particle in one-dimensional potential well is given by $\sqrt{\frac{2}{a}} \sin \frac{n\pi x}{a}$, $0 < x < a$, when a potential of $V(x) = \frac{\cos \pi x}{a}$ is applied, the change in first order energy is

(1) zero (2) $\frac{a}{\pi}$
 (3) $\frac{2\pi}{a}$ (4) $\frac{a}{2\pi}$

29. There are only three bound states for a particle of mass m in a one-dimensional potential well of the form shown in figure. The depth V_0 of the potential satisfies



(1) $\frac{2\pi^2 \hbar^2}{ma^2} < V_0 < \frac{9\pi^2 \hbar^2}{2ma^2}$ (2) $\frac{\pi^2 \hbar^2}{ma^2} < V_0 < \frac{2\pi^2 \hbar^2}{ma^2}$
 (3) $\frac{2\pi^2 \hbar^2}{ma^2} < V_0 < \frac{8\pi^2 \hbar^2}{ma^2}$ (4) $\frac{2\pi^2 \hbar^2}{ma^2} < V_0 < \frac{50\pi^2 \hbar^2}{ma^2}$

30. If $\psi = \sqrt{\frac{2}{L}} \cos \frac{\pi x}{L}$, then $\langle x \rangle$ in the limit $-\frac{L}{2} < x < \frac{L}{2}$ is

(1) $\frac{3}{4L}$ (2) 0
 (3) $\frac{1}{4L}$ (4) $\frac{L}{2}$

31. A particle constrained to move along the x -axis is described by the wave function

$\psi(x) = 2x$; $0 < x < 1$

$\psi(x) = 0$; elsewhere

What is the probability of finding the particle within the interval $(0, 0.4)$?

(1) 0.85 (2) 0.085
 (3) 0.0085 (4) 0.00085

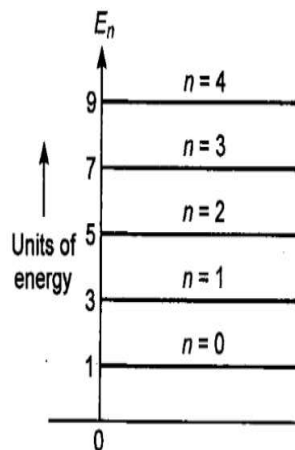
32. The energy separation between two successive states with quantum numbers n and $(n-1)$ of an infinite potential well is given by

(1) $\Delta E \propto (2n+1)$ (2) $\Delta E \propto n$
 (3) $\Delta E \propto \sqrt{2n+1}$ (4) $\Delta E \propto (2n-1)$

Section 4:

Harmonic oscillator, anharmonic oscillator and rigid rotor:

1. The figure shown in the energy level diagram corresponding to a



- (1) particle in a box (2) particle tunnelling
 (3) harmonic oscillator (4) hydrogen atom

2. If E_0 is the zero-point energy of a harmonic oscillator of frequency ν and h is Planck's constant then its energy in the $n = 2$ state will be

(1) $(E_0 + h\nu)$ (2) $2E_0$
 (3) $4E_0$ (4) $(E_0 + 2h\nu)$

3. A particle of mass m is in a simple harmonic oscillator potential $V = x^2$. If the ground state wave function is Ae^{-ax^2} , what is the expression for constant a equal to?