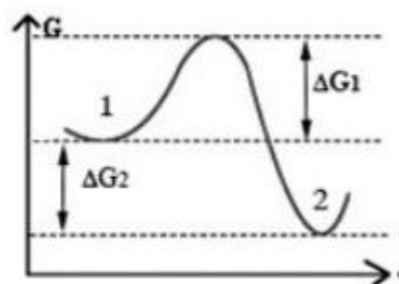# DU PhD in Chemistry

1) With reference to the figure below, which represents the Gibbs free energy along a reaction path for a single phase transformation from state 1 to state 2,

[Question ID = 51]

1. rate = C exp(-ΔG_1/RT)

    [Option ID = 201]
2. rate = C exp(-ΔG_2/RT)

    [Option ID = 202]
3. rate = C exp(-{ΔG_1+ ΔG_2}/RT)

    [Option ID = 203]
4. rate = C exp(-{ΔG_1- ΔG_2}/RT)

    [Option ID = 204]

2) The degeneracy of a particle in a cubic box having energy three times that of the lowest energy state is**[Question ID = 52]**

1. 1 [Option ID = 205]
2. 2 [Option ID = 206]
3. 3 [Option ID = 207]
4. 4 [Option ID = 208]

3) Which of the following functions is an eigenfunction of the operator *d/dx*? *k* is a constant.

[Question ID = 53]

1. $\exp(ikx)$

    [Option ID = 209]
2. kx^2

    [Option ID = 210]
3. $\sin kx$

    [Option ID = 211]
4. $\exp(kx^2)$

    [Option ID = 212]

4) Three non-interacting particles, each with spin ½, are moving in a one dimensional box of length L. The energy of the lowest energy state of the system is

[Question ID = 54]

1. $\dfrac{h^2}{4mL^2}$

    [Option ID = 213]

2. $\dfrac{h^2}{2mL^2}$

    [Option ID = 214]

3. $\dfrac{3h^2}{4mL^2}$

    [Option ID = 215]

4. $\dfrac{5h^2}{4mL^2}$

    [Option ID = 216]

5) The order of the N-O bond strengths in NO, NO^+, and NO^- is**[Question ID = 55]**

1. $NO > NO^+ > NO^-$ [Option ID = 217]

2. NO$^+$ > NO > NO$^-$ [Option ID = 218]
3. NO$^+$ > NO$^-$ > NO [Option ID = 219]
4. NO$^-$ > NO > NO$^+$ [Option ID = 220]

6) If the energy of a particle can be either 1, 2, 3, 4 or 5 units with probability 1/15, 2/15, 3/15/ 4/15 and 5/15, respectively, the average energy of the particle is[Question ID = 56]
1. 0.5 [Option ID = 221]
2. 3.0 [Option ID = 222]
3. 3.7 [Option ID = 223]
4. 4.3 [Option ID = 224]

7) In terms of the partition function Z of a system of particles, the average energy <E> is expressed as

[Question ID = 57]

1. $< E >= \dfrac{\partial Z}{\partial \beta}$

[Option ID = 225]

2. $< E >= -\dfrac{\partial Z}{\partial \beta}$

[Option ID = 226]

3. $< E >= -\dfrac{\partial \ln Z}{\partial \beta}$

[Option ID = 227]

4. $< E >= \dfrac{\partial \ln Z}{\partial \beta}$

[Option ID = 228]

8) State which of the following statements about Bose-Einstein (BE) statistics is FALSE[Question ID = 58]
1. BE statistics is for particles with integral spin. [Option ID = 229]
2. BE statistics can be applied to photons. [Option ID = 230]
3. Bosons obey Pauli's Exclusion Principle. [Option ID = 231]
4. The wave function of bosons is symmetric. [Option ID = 232]

9) The equation for the evaluation of β in the Maxwell-Boltzmann distribution law is

[Question ID = 59]
1. $\beta = 1/kT$.

[Option ID = 233]
2. $\beta = -1/kT$.

[Option ID = 234]
3. $\beta = kT$.

[Option ID = 235]
4. $\beta = 2/kT$.

[Option ID = 236]

10) According to the Debye-Hückel limiting law, if the concentration of a dilute aqueous solution of KCl is increased 4-fold, the value of $\log \gamma_{\pm}$ will

[Question ID = 60]
1. decrease by a factor of 2

[Option ID = 237]
2. increase by a factor of 2

[Option ID = 238]
3. decrease by a factor of 4

[Option ID = 239]
4. increase by a factor of 4

[Option ID = 240]

11) In the first excited state, S$_1$, acetylene has a *trans* bent configuration compared to its linear S$_0$ ground state, and its CC bond length also increases from 1.21 Å to 1.34 Å. The S$_1 \leftarrow$ S$_0$ absorption spectrum will show

[Question ID = 61]
1. no vibrational coarse structure.

[Option ID = 241]
2. a sharp peak.

[Option ID = 242]
3. a continuum.

[Option ID = 243]

4. a broad vibrational progression.

[Option ID = 244]

12) ClO_2 molecule was trapped in a solid. Its ground electronic state is known to be B_1. Light polarized parallel to the y-axis excited the molecule to an upper state. The upper state is

	E	C_2 (z)	σ_v(xz)	σ_v(yz)	linear, rotations	quadratic
A_1	1	1	1	1	z	x^2, y^2, z^2
A_2	1	1	-1	-1	R_z	xy
B_1	1	-1	1	-1	x, R_y	xz
B_2	1	-1	-1	1	y, R_x	yz

Character table for C_{2v} point group

chlorine dioxide
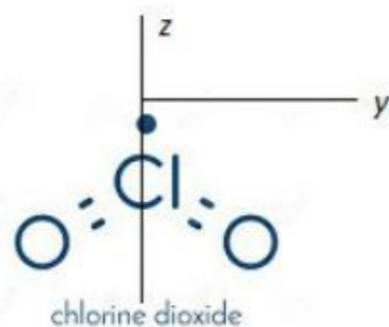
[Question ID = 62]

1. A_1

[Option ID = 245]

2. A_2

[Option ID = 246]

3. B_1

[Option ID = 247]

4. B_2

[Option ID = 248]

13) The term symbol for the ground state of B_2^+ is $^2\Sigma_g^+$. The total spin and total orbital angular momentum are, respectively,

[Question ID = 63]

1. ½, 0

[Option ID = 249]

2. ¾, 0

[Option ID = 250]

3. √3/2, 0

[Option ID = 251]

4. 2, 1

[Option ID = 252]

14) Interpret the observed IR and Raman frequencies for an XY_2 molecule

V/CM^{-1}	IR	Raman
2224	vs, PR	s, depol
1285	vs, PR	vs, pol
568	s, PQR	-

The structure is

[Question ID = 64]

1. linear XYY

[Option ID = 253]

2. linear YXY

[Option ID = 254]

3. bent XYY

[Option ID = 255]

4. bent YXY

[Option ID = 256]

15) Assuming that the force constants of double and triple bonds are roughly two and three times, respectively, that of single bonds, the ratio of the stretching frequencies of the C-C, C=C and C≡C bonds is

[Question ID = 65]

1. 1:2:3

[Option ID = 257]

2. 1:1.4:1.7

[Option ID = 258]

3. 3:2:1

[Option ID = 259]

4. 1:4:9

[Option ID = 260]

16) The mean time for the $2p \rightarrow 1s$ spectral transition is 1.6×10^{-9} s, while the mean time for the $2s \rightarrow 1s$ transition is 0.14 s. This is because

[Question ID = 66]

1. the $2p \rightarrow 1s$ transition is forbidden, but $2s \rightarrow 1s$ is allowed.

[Option ID = 261]

2. the $2p \rightarrow 1s$ transition is allowed, but $2s \rightarrow 1s$ is forbidden.

[Option ID = 262]

3. the $2p \rightarrow 1s$ transition is allowed, and $2s \rightarrow 1s$ is also allowed.

[Option ID = 263]

4. the $2p \rightarrow 1s$ transition is forbidden, and the $2s \rightarrow 1s$ transition is also forbidden.

[Option ID = 264]

17) The vibrations of diatomic molecules are usually modelled by a harmonic potential. If the potential is given by x^2, the correct statement is:

[Question ID = 67]

1. The force constant is 2 and the force is 2x.

[Option ID = 265]

2. The force constant is 2 and the force is -2x.

[Option ID = 266]

3. The force constant is -1 and the force is -2x.

[Option ID = 267]

4. The force constant is 1 and the force is 2x.

[Option ID = 268]

18) Major product of the following reaction is:

[Question ID = 68]

1.

[Option ID = 269]

2.

[Option ID = 270]

3.

[Option ID = 271]

4.
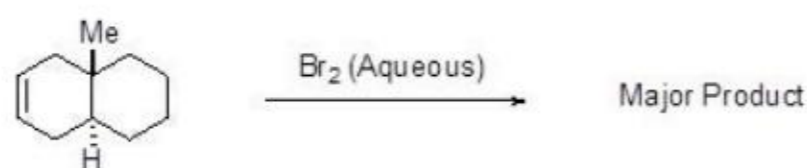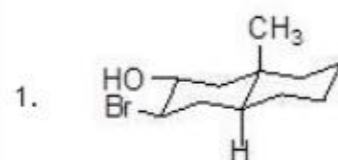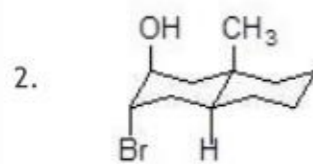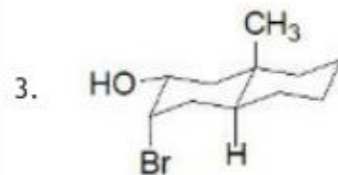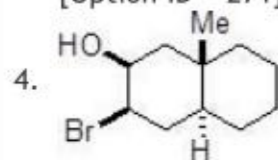
[Option ID = 272]

19) Which of the following conformer(s) will predominate(s) in dimethylsulfoxide (DMSO) solvent?
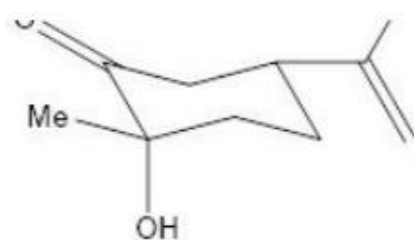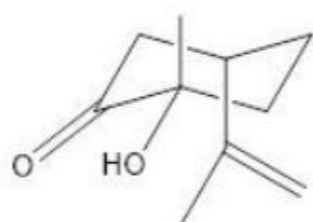
(A)   (B)

[Question ID = 69]

1. (B) only

   [Option ID = 273]

2. (A) only
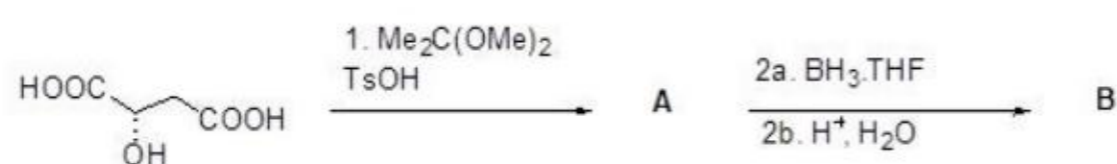
   [Option ID = 274]

3. (B) is 50% and (A) in 50 %

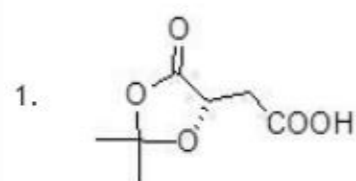   [Option ID = 275]

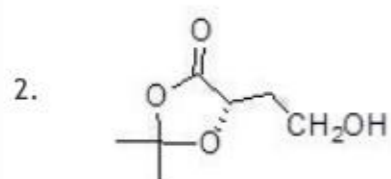4. (B) is 78% and (A) is 22%

   [Option ID = 276]

20) Consider the following reaction:

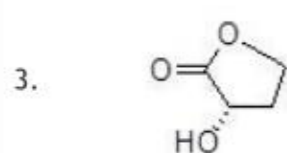**[Question ID = 70]**

1.

   [Option ID = 277]

2.

   [Option ID = 278]

3.

   [Option ID = 279]

4.
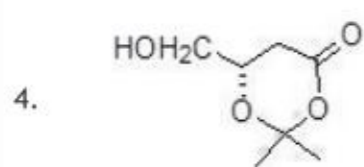
   [Option ID = 280]

21) Which one of the following reducing reagents will not give below given product?

[Question ID = 71]

1. 9-Borobicyclo[3,3,1]nonane (9-BBN), THF, 0°C

   [Option ID = 281]

2. NaBH$_4$, CeCl$_3$, MeOH

3. LiAlH(OMe)₃, THF, 0°C

4. NaBH₄, EtOH, 0°C

22) The major product formed in the following reaction is:

1. KCN, DMSO
2a. DIBAL (1.2 eq.), CH₂Cl₂, -78°C to rt
2b. Rochelle's salt workup

Product

[Question ID = 72]

1.

2.

3.

4.
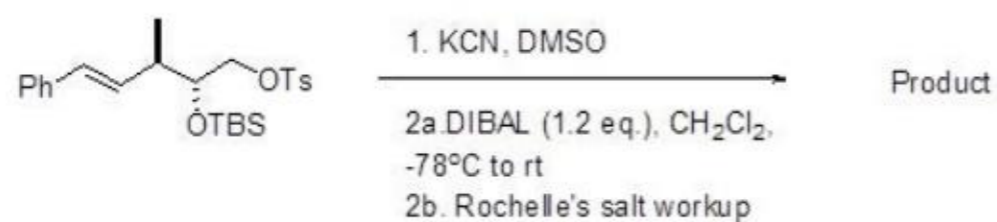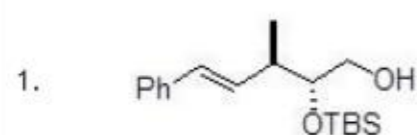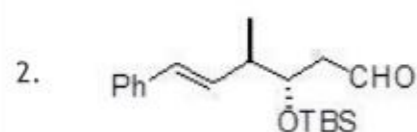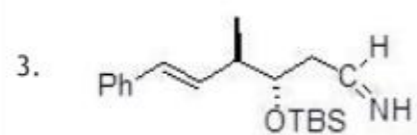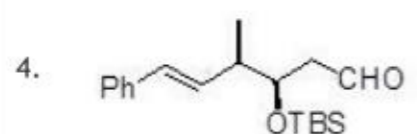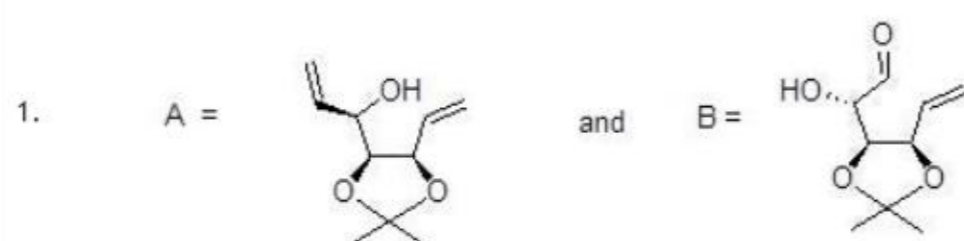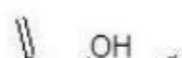
23) Consider the following reaction
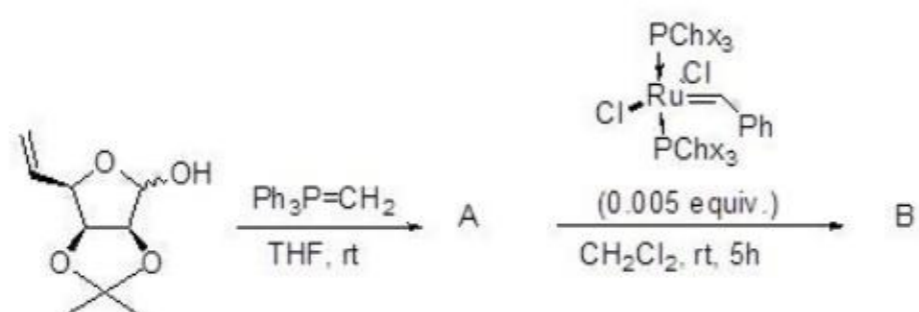
The products A and B are:

[Question ID = 73]

1.   A =

and   B =

2. A = and B =

[Option ID = 290]

3. A = and B =
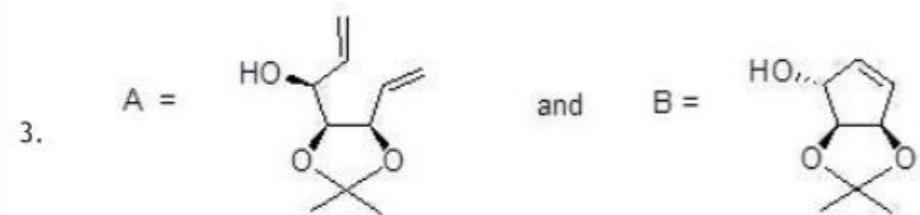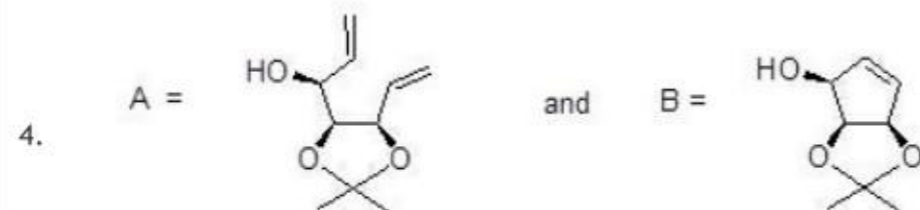
[Option ID = 291]

4. A = and B =
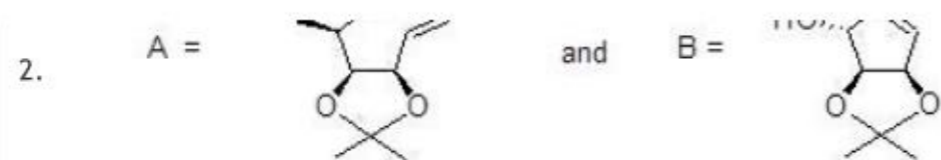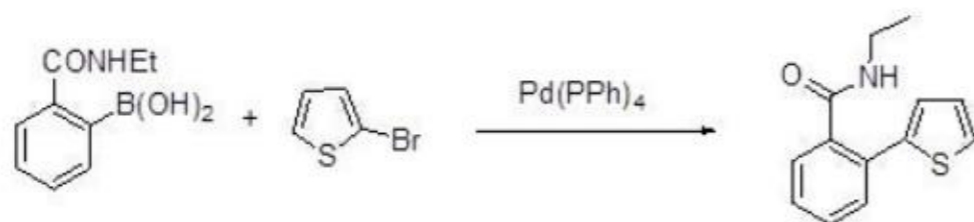
[Option ID = 292]

24) The following reaction is known as:

[Question ID = 74]

1. Suzuki reaction

[Option ID = 293]

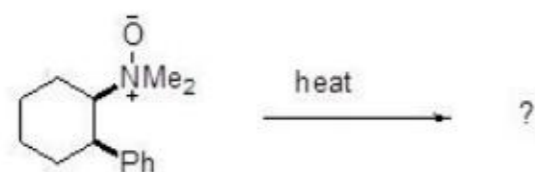2. Heck reaction

[Option ID = 294]
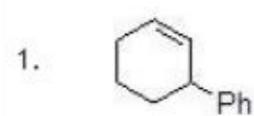
3. Stille coupling

[Option ID = 295]

4. Sonogashira coupling

[Option ID = 296]

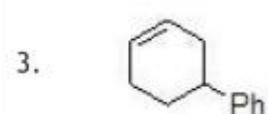25) Which one of the following products will be major product in the below given reaction?

[Question ID = 75]

1.
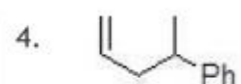
[Option ID = 297]

2.

[Option ID = 298]

3.

[Option ID = 299]

4.

[Option ID = 300]

26) Which one of the following is suitable reagent for the below given reaction?

[Question ID = 76]
1. ^{t}-BuOOH, Ti(O^{i}Pr)$_4$, (+)-Diethyl tartrate

[Option ID = 301]
2. ^{t}-BuOOH, (+)-Diethyl tartrate

[Option ID = 302]
3. ^{t}-BuOOH, Ti(O^{i}Pr)$_4$, (-)-Diethyl tartrate

[Option ID = 303]
4. ^{t}-BuOOH, Ti(O^{i}Pr)$_4$

[Option ID = 304]

27) Consider the following addition reaction:
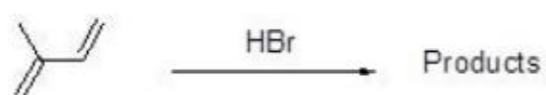
The least favored produt is:

[Question ID = 77]
1. 3-Bromo-3-methyl-1-butene

[Option ID = 305]
2. 1-Bromo-3-methyl -2-butene

[Option ID = 306]
3. 3-Bromo-2-methyl-1-butene

[Option ID = 307]
4. 4-Bromo-2-methyl-1-butene

[Option ID = 308]

28) Which one is the correct order of potential effetiveness as leaving group in the nuleophilic substitution reaction?

[Question ID = 78]
1. II > I > III > IV

[Option ID = 309]
2. I > III > II> IV

[Option ID = 310]
3. IV > II > III > I

[Option ID = 311]
4. III > I > II > IV

[Option ID = 312]

29) Nitration of cinnamic acid will give the product(s):

[Question ID = 79]
1. 2-Nitro-cinnamic acid only

[Option ID = 313]
2. 3-Nitro-cinnamic acid only

[Option ID = 314]
3. 4-Nitro-cinnamic acid only

4. 2-nitro-cinnamic acid and 4-nitro-cinnamic acid formed more than 3-nitro-cinnamic acid

[Option ID = 316]

30) An organic compound having molecular formula $C_5H_{10}O$ and it shows peak at 3410 cm^{-1} in FT-IR. ^{1}H-NMR (300 MHz, CDCl$_3$): $\square$ = 6.05 (dd, 1H), 5.02 (dd, 1H), 4.09 (dd, 1H), 2.80 (s, D$_2$O exchangeable), 1.3 (s, 6H) ppm. ^{13}C-NMR: $\square$ =150, 110, 70, 29 ppm. Dept-135: $\square$ = 150(+), 110 (-), 29 (+). The structure of the compound will be:

[Question ID = 80]

1.

[Option ID = 317]

2.

[Option ID = 318]
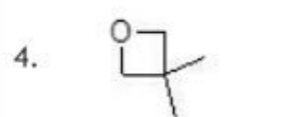
3.

[Option ID = 319]

4.
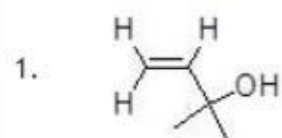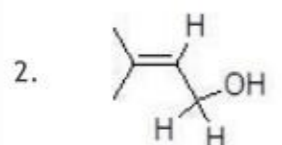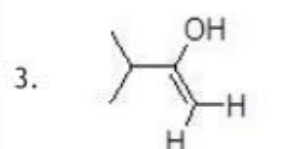
[Option ID = 320]

31) Cyclohexanone and cyclopetanone give one common m/z base peak. The value of the peak in m/z is:

[Question ID = 81]
1. 84

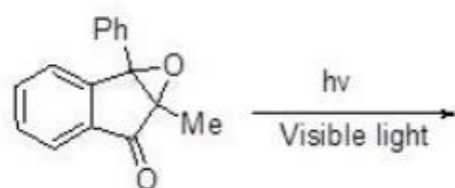[Option ID = 321]
2. 42

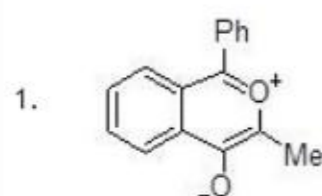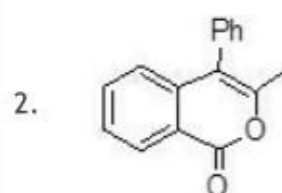[Option ID = 322]
3. 55

[Option ID = 323]
4. 83

[Option ID = 324]

32) The principal product of the following reaction is:

[Question ID = 82]

1.

[Option ID = 325]

2.

[Option ID = 326]

3.

[Option ID = 327]

4.
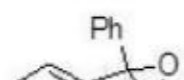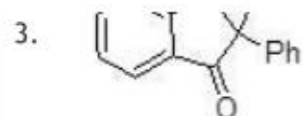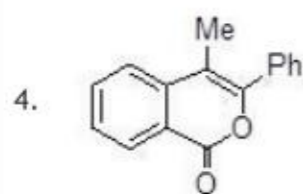
[Option ID = 328]

33) In the following reaction A and C are interconvered under thermal conditions through cyclobutane B.
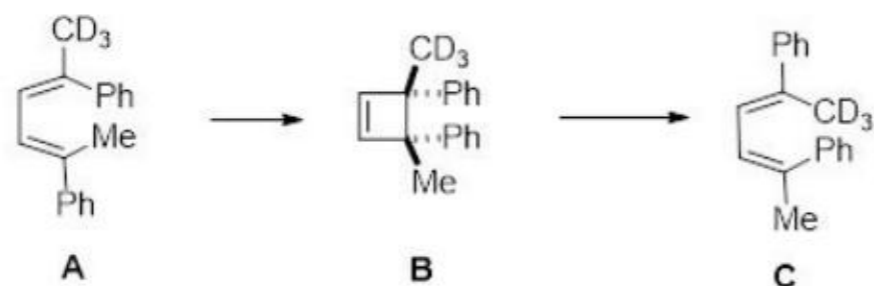
[Question ID = 83]
1. Ring closure of **A** and ring opening of **B** both will be conrotatory proccesses

[Option ID = 329]
2. Ring closure of **A** will be disrotatory process and ring opening of **B** will be conrotatory proccess

[Option ID = 330]
3. Ring closure of **A** and ring opening of **B** both will be disrotatory proccesses

[Option ID = 331]
4. Ring closure of **A** will be conrotatory proccess and ring opening of **B** will be disrotatory process

[Option ID = 332]

34) The absolute configuration of below given compunds will be:
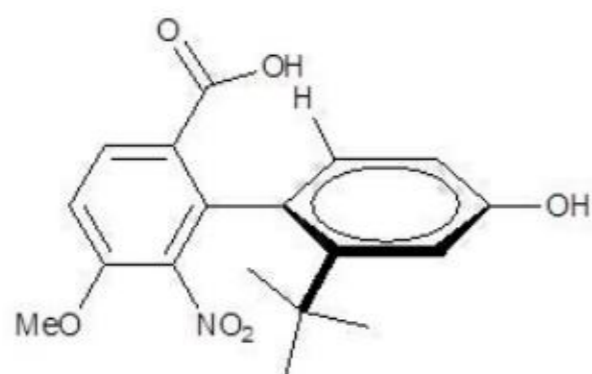
[Question ID = 84]
1. R

[Option ID = 333]
2. S

[Option ID = 334]
3. R, S

[Option ID = 335]
4. S, S

[Option ID = 336]

35) Which ordering correctly shows the variation in rates of water exchange in high spin aqua complexes $[M(OH_2)_6]$?

[Question ID = 85]
1. $Co^{2+} > Cr^{2+}$

[Option ID = 337]
2. $V^{2+} > Co^{2+}$

[Option ID = 338]
3. $Cr^{3+} > Fe^{3+}$

[Option ID = 339]
4. $Cr^{2+} > Cr^{3+}$

[Option ID = 340]

36) The principal axis C_4 is present in

[Question ID = 86]
1. BF_3

[Option ID = 341]
2. SnO_2

[Option ID = 342]
3. BrF_5

[Option ID = 343]
4. C_6H_6

[Option ID = 344]

37) Which one of the following sentence is false about EDTA?

[Question ID = 87]
1. Alkali medium is required for complexation because EDTA will ionize better in alkali medium.

[Option ID = 345]
2. EDTA form complexes with all metal ions.

[Option ID = 346]
3. Solubility of EDTA is lower than its disodium counterpart.

[Option ID = 347]
4. Alkali medium is required for complexation because EDTA will ionize more in acidic medium.

[Option ID = 348]

38) The non-covalent interaction present in the Na^+ -crown ether complex is due to,

[Question ID = 88]
1. ion-ion

[Option ID = 349]
2. ion-dipole

[Option ID = 350]
3. dipole-dipole

[Option ID = 351]
4. hydrogen bonding

[Option ID = 352]

39) The series identifying the thiophilic heavy metal ions,

[Question ID = 89]
1. Cu^{1+}, Hg^{2+}, Tl^{1+}

[Option ID = 353]
2. Ti^{4+}, La^{3+}, Si^{4+}

[Option ID = 354]
3. V^{5+}, Te^{6+}, Y^{3+}

[Option ID = 355]
4. Nb^{5+}, Sc^{3+}, B^{3+}

[Option ID = 356]

40) A metal X on heating in nitrogen gas gives Y. Y on treatment with H_2O gives a colourless gas which when passed through $CuSO_4$ solution gives blue colour. Y is

[Question ID = 90]
1. $Mg(NO_3)_2$

[Option ID = 357]
2. Mg_3N_2

[Option ID = 358]
3. $MgCl_2$

[Option ID = 359]
4. MgO

[Option ID = 360]

41) Which of the following statement is true for the diffraction pattern in the crystal lattice?

[Question ID = 91]
1. Diffraction patterns are linear space.

[Option ID = 361]
2. Diffraction patterns possess a center of symmetry

[Option ID = 362]

3. Diffraction pattern does not have center of symmetry

[Option ID = 363]

4. Diffraction patterns contain α-rays.

[Option ID = 364]

42) Which is the sequence showing the correct order of increasing intensity for the d-d transition?

[Question ID = 92]

1. $CoCl_4^{2-}$ > $[Co(NH_3)_6]^{3+}$ > $[Co(NH_3)_6]^{2+}$ > $[Co(H_2O)_6]^{2+}$

[Option ID = 365]

2. $[Co(H_2O)_6]^{2+}$ > $[Co(NH_3)_6]^{3+}$ > $CoCl_4^{2-}$ > $[Co(NH_3)_6]^{2+}$

[Option ID = 366]

3. $[Co(NH_3)_6]^{2+}$ > $[Co(H_2O)_6]^{2+}$ > $CoCl_4^{2-}$ > $[Co(NH_3)_6]^{3+}$

[Option ID = 367]

4. $[Co(NH_3)_6]^{3+}$ > $[Co(NH_3)_6]^{2+}$ > $CoCl_4^{2-}$ > $[Co(H_2O)_6]^{2+}$

[Option ID = 368]

43) The equilibrium shift towards the products in $Cr_2O_7^{2-} \leftrightharpoons CrO_4^{2-}$

[Question ID = 93]

1. occurs in acidic medium

[Option ID = 369]

2. occurs in basic medium

[Option ID = 370]

3. occurs in neutral medium

[Option ID = 371]

4. does not exist

[Option ID = 372]

44) Which one of the following ion shows kinetic masking?

[Question ID = 94]

1. Co^{2+}

[Option ID = 373]

2. Cu^{2+}

[Option ID = 374]

3. Cr^{3+}

[Option ID = 375]

4. Fe^{3+}

[Option ID = 376]

45) The p^5 electronic configuration is equivalent to the term in ground state

[Question ID = 95]

1. ^3P

[Option ID = 377]

2. ^2P

[Option ID = 378]

3. ^3F

[Option ID = 379]

4. ^4P

[Option ID = 380]

46) The molecule which has an inversion center and S_6-axis is

[Question ID = 96]

1. Chlorobenzene

[Option ID = 381]

2. p-dichlorobenzene

[Option ID = 382]

3. 1,3, 5- trichlorobenzene

[Option ID = 383]

4. Chair form of cyclohexane

[Option ID = 384]

47) The type of intermolecular interaction present in the herring bone packing of benzene,

[Question ID = 97]

1. Cation – π

   [Option ID = 385]
2. anion – π

   [Option ID = 386]
3. dipole-ion

   [Option ID = 387]
4. π – π

   [Option ID = 388]

48) Which one of the following statement is correct?

[Question ID = 98]

1. A dissociative mechanism is a 2-step mechanism with the leaving group departing in the second step.

   [Option ID = 389]
2. An associative mechanism is a 2-step mechanism; the intermediate has a lower coordination number than the starting complex.

   [Option ID = 390]
3. In a dissociative interchange mechanism, bond breaking dominates over bond formation

   [Option ID = 391]
4. In an associative interchange mechanism, the entering group associates with the substrate after the leaving group has departed.

   [Option ID = 392]

49) Which one of the following cannot show linkage isomerism?

[Question ID = 99]

1. Cl^-

   [Option ID = 393]
2. SCN^-

   [Option ID = 394]
3. CN^-

   [Option ID = 395]
4. NH_3

   [Option ID = 396]

50) Match List I with List II based on the molecular symmetry

List I	List II
Molecule	**Point group**
A. $(Si_4O_4)^{4-}$	I. C_{2v}
B. Hg_2Cl_2	II. C_{3v}
C. $SeCl_3^+$	III. $D_{\infty h}$
D. NO_2F (N-central metal atom)	IV. T_d

Choose the correct answer from the options given below:

[Question ID = 100]

1. A - III, B - I, C - IV, D -II

   [Option ID = 397]
2. A - II, B - III, C -I, D - II

   [Option ID = 398]
3. A - IV, B - I, C - III, D - II

   [Option ID = 399]
4. A - IV, B - III, C - II, D - I

   [Option ID = 400]