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Exam Date: **07-Oct-2020**
Exam Time: **09:00-12:00**
Examination: **1. Course Code - Ph.D.**
2. Field of Study - Chemical Science (CHEH)

SECTION 1 - PART A

Question No.1 (Question Id - 12)

A solution with concentration 0.002 M, having molar absorptivity of 313 M^{-1} cm^{-1} kept in a cell with 4.00 cm path length. The transmittance for the solution will be :

(A) ○ 2.50
(B) ○ **$10^{-2.50}$ (Correct Answer)**
(C) ○ $10^{2.50}$
(D) ○ $10^{1.50}$
(E) ○ $10^{-1.50}$

Question No.2 (Question Id - 2)

The solubility product (K_{sp}) of mercurous chloride (Hg_2Cl_2) is 1.2 x 10^{-18}. The concentration of $[Hg_2]^{2+}$ and $[Cl^-]$ is found to be respectively :

(A) ○ **6.7 x 10^{-7} M and 13.4 x 10^{-7} M (Correct Answer)**
(B) ○ 13.4 x 10^{-7} M and 6.7 x 10^{-7} M
(C) ○ 6.7 x 10^{-9} M and 13.4 x 10^{-9} M
(D) ○ 13.4 x 10^{-9} M and 6.7 x 10^{-9} M
(E) ○ 1.2 x 10^{-7} M and 2.4 x 10^{-7} M

Question No.3 (Question Id - 3)

The following statement is correct concerning the IR spectrum of nitrite and isocyanate groups :

(A) ○ **The - C ≡ N and - NCO groups absorb in the region of 2260 - 2240 cm^{-1} and 2275 - 2240 cm^{-1}, respectively. (Correct Answer)**
(B) ○ The - C ≡ N and - NCO groups absorb in the region of 2590 - 2550 cm^{-1} and 2275 - 2240 cm^{-1}, respectively.
(C) ○ The - C ≡ N and - NCO groups absorb in the region of 1690 - 1590 cm^{-1} and 2260 - 2240 cm^{-1}, respectively.
(D) ○ The - C ≡ N and - NCO groups absorb in the region of 2275 - 2240 cm^{-1} and 2590 - 2550 cm^{-1},respectively.
(E) ○ The - C ≡ N and - NCO groups absorb in the region of 1690 - 1590 cm^{-1} and 2260 - 2360 cm^{-1},respectively.

Question No.4 (Question Id - 6)

In the mass spectrum of trifluoroacetic acid, CF_3CO_2H, intense peaks are observed at m/z = 69 and 45 (base peak) in addition of other peaks. The peak at m/z = 69 is accompanied by a peak at m/z = 70 which is about 1.1% the intensity of the peak at m/z = 69. Which statement is inconsistent with these data ?

(A) ○ C - C bond cleavage occurs
(B) ○ Fluorine is monotopic
(C) ○ $[CO_2H]^+$ is a fragment
(D) ○ **CF_3CO_2H fragments by sequential loss of F atoms (Correct Answer)**
(E) ○ $[CF_3]^+$ is a fragment

Question No.5 (Question Id - 11)

With increase in temperature the viscosities of gases and liquids respectively.

(A) ○ **increase, decrease (Correct Answer)**
(B) ○ decrease, increase

(C) ○ decrease, decrease
(D) ○ increase, increase
(E) ○ unaffected by temperature

Question No.6 (Question Id - 10)
Mixture containing A, B and C was injected into a gas chromatograph. "A" gave a sharp peak in 40 seconds, "B" and "C" gave peaks at 250 and 330 seconds respectively. The adjusted retention time are :

(A) ○ 290 s and 370 s
(B) ○ 290 s and 210 s
(C) ○ 370 s and 290 s
(D) ○ **210 s and 290 s (Correct Answer)**
(E) ○ 80 s and 40 s

Question No.7 (Question Id - 4)
The ^{1}H NMR spectrum of a compound 'A' shows a doublet and a septet. Which of the following statements is true ?

(A) ○ The spectroscopic data are consistent with 'A' containing a n-propyl group.

(B) ○ **The spectroscopic data are consistent with 'A' being $(CH_3)_2CHCl$. (Correct Answer)**
(C) ○ The spectroscopic data are consistent with 'A' containing CH_3CH_2 group.

(D) ○ The spectroscopic data are consistent with 'A' being $(CH_3)_2CCl_2$.
(E) ○ The spectroscopic data are consistent with 'A' containing $(CH_3)_3C$ group.

Question No.8 (Question Id - 8)
What will be the decreasing order of absorption of wavelength of light in the visible region for the following complexes ?

A. $[Co(NH_3)_6]^{3+}$

B. $[Co(H_2O)_6]^{3+}$

C. $[Co(CN)_6]^{3-}$

Choose the **correct** answer from the options given below

(A) ○ A > B > C
(B) ○ C > A > B
(C) ○ B > C > A
(D) ○ A > C > B
(E) ○ **B > A > C (Correct Answer)**

Question No.9 (Question Id - 5)
A 0.2 M solution of an optically active compound. 'C' has an observed rotation in a 10 cm cell of (+) 0.6°. The specific rotation of the compound is 20° at room temperature and at 592 nm. The molecular weight of the compound 'C' is :

(A) ○ **150 (Correct Answer)**
(B) ○ 200
(C) ○ 120
(D) ○ 240
(E) ○ 160

Question No.10 (Question Id - 14)
The lead (Pb) content in the replicate detemination of a blood sample was found to be 0.750, 0.754, 0.750 ppm. The standard deviation will be :

(A) ○ 0.023
(B) ○ **0.0023 (Correct Answer)**
(C) ○ 0.00023
(D) ○ 0.0032
(E) ○ 0.032

Question No.11 (Question Id - 13)

In an experiment, absorbance measurements were recorded as 0.588, 0.580, 0.586, 0.573, 0.575. The random error for the third result will be :

(A) ○ -0.5809

(B) ○ 0.5809

(C) ○ -0.0056

(D) ○ **+0.0056**

(Correct Answer)

(E) ○ 0.001

Question No.12 (Question Id - 9)

A mineral absorbs ultraviolet light and then emits a photon of wavelength 540 nm after converting some of absorbed light energy to heat. The energy of emission is :

(A) ○ **3.68×10^{-19} J (Correct Answer)**

(B) ○ 1.84×10^{-19} J

(C) ○ 7.36×10^{-19} J

(D) ○ 5.40×10^{-19} J

(E) ○ 2.70×10^{-19} J

Question No.13 (Question Id - 1)

In the extraction of a solution of 5.0 gms of butanoic acid in 100 ml of water at 15°C, 100 ml of benzene at 15°C is used. Partition coefficient (K) of butanoic acid between water and benzene is $\frac{1}{3}$ at 15°C. A single extraction with benzene, w (gms) remain in the aqueous layer. w in gms should be :

(A) ○ 1.0 gm

(B) ○ 2.0 gms

(C) ○ **1.25 gms (Correct Answer)**

(D) ○ 0.5 gm

(E) ○ 3.0 gms

Question No.14 (Question Id - 7)

When a mixture of NaCl, Conc. H_2SO_4, and $K_2Cr_2O_7$ is heated in a dry test tube, deep red vapour of A evolved. This vapour (A) dissolved in aqueous NaOH gave a yellow solution, which upon treatment with $AgNO_3$ formed a brick-red precipitate (B). A and B are, respectively :

(A) ○ CrO_2Cl_2 and $Ag_2Cr_2O_7$

(B) ○ **CrO_2Cl_2 and Ag_2CrO_4 (Correct Answer)**

(C) ○ Na_2 $[CrOCl_5]$ and $Ag_2Cr_2O_7$

(D) ○ Na_2 $[CrOCl_5]$ and Ag_2CrO_4

(E) ○ CrOCl and $AgCrO_4$

Question No.15 (Question Id - 15)

For the systematic error, which statement among the following is not correct ?

(A) ○ It is determinate error

(B) ○ **It is indeterminate error (Correct Answer)**

(C) ○ It is reproducible

(D) ○ It arises due to uncalibration

(E) ○ It arises due to chemical contamination

SECTION 2 - PART B

Question No.1 (Question Id - 41)

The point group of H_2O_2, if it is in trans form :

(A) ○ C_{2u}

○

(B) D_{2h}

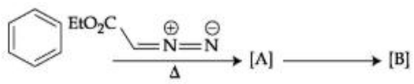
(C) ○ **C_{2h} (Correct Answer)**

(D) ○ D_{2d}

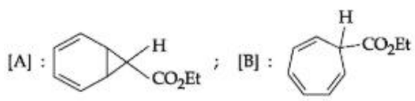
(E) ○ C_2

Question No.2 (Question Id - 27)

Predict the correct structures [A] and [B], and the correct statement for the following reaction :

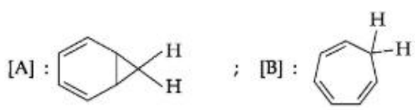


(A) ○



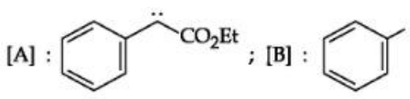
The reaction goes via a radical intermediate.

(B) ○



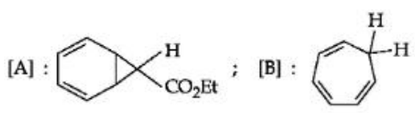
The reaction goes through a carbene intermediate and an electrocyclic ring opening.

(C) ○



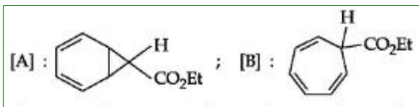
The reaction goes through a carbene intermediate.

(D) ○



The reaction goes through a radical mechanism.

(E) ○

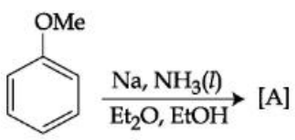


The reaction goes through a carbene intermediate and an electrocyclic ring opening.

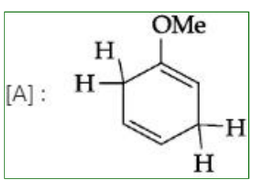
(Correct Answer)

Question No.3 (Question Id - 16)

In the reduction of aromatic rings with metal, the substituents influence the regioselectivity of the reaction.
The major product formed in the following reaction is :

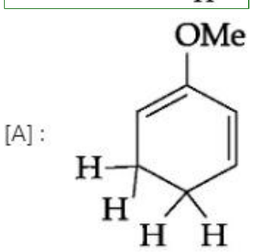


(A) ○

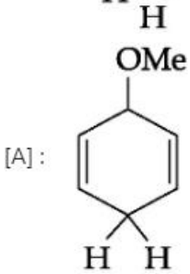


(Correct Answer)

(B) ○

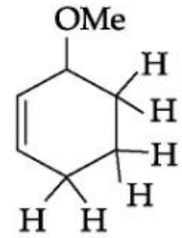


(C) ○



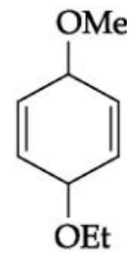
(D) ○

[A] :



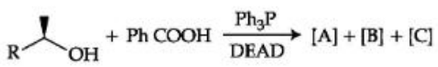
(E) ○

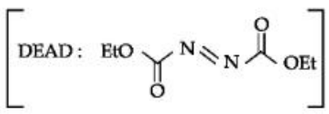
[A] :



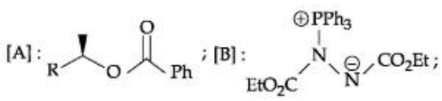
Question No.4 (Question Id - 22)

A secondary alcohol is reacted with an aromatic acid in the presence of PPh_3 and DEAD. The following products are formed. Choose the correct products [A], [B] and [C].



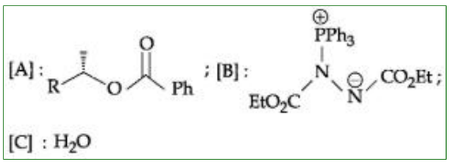


(A) ○



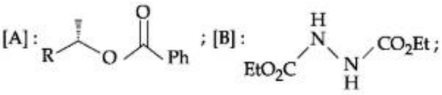
[C] : H_2O

(B) ○



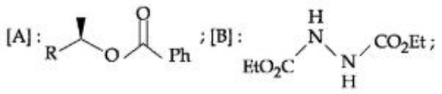
(Correct Answer)

(C) ○



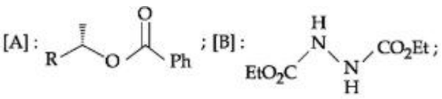
[C] : $Ph_3P=O$

(D) ○



[C] : $Ph_3P=O$

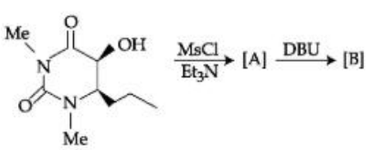
(E) ○



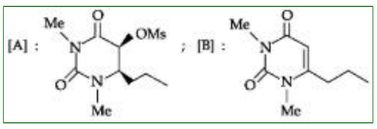
[C] : H_2O

Question No.5 (Question Id - 25)

The following reaction steps are carried out to prepare a synthetic analogue of uracil. The products formed [A] and [B] are :

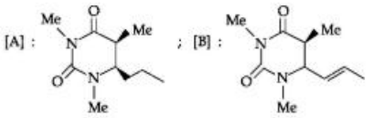


(A) ○

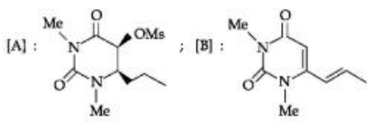


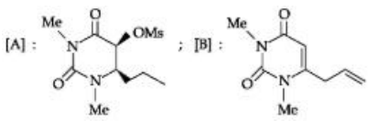
(Correct Answer)

(B) ○



(C) ○

(D) ○ 

(E) ○ 

Question No.6 (Question Id - 49)

For an hexagonal crystal system.

(A) ○ a = b = c ; α = β = γ = 90°

(B) ○ **a = b ≠ c ; α = β = 90° γ = 120° (Correct Answer)**

(C) ○ a = b = c ; α = β = 90° γ = 120°

(D) ○ a = b ≠ c ; α = β = γ = 90°

(E) ○ a ≠ b ≠ c ; α = γ = 90° ≠ β

Question No.7 (Question Id - 38)

Release of O_2 from oxyhemoglobin is favoured by :

(A) ○ High pH, low conc. of CO_2 and high temperature

(B) ○ High pH, low conc. of CO_2 and low temperature

(C) ○ Low pH, low conc. of CO_2 and high temperature

(D) ○ High pH, high conc. of CO_2 and low temperature

(E) ○ **Low pH, high conc. of CO_2 and high temperature (Correct Answer)**

Question No.8 (Question Id - 40)

An excited atom has a mean life of 10^{-8} s and radiates a photon while coming down to the ground state. The inherent uncertainty in the frequency is [h = 6.626 x 10^{-34}; Js]

(A) ○ 1.054 x 10^{+34} Hz

(B) ○ 8 x 10^{-8} Hz

(C) ○ **8 x 10^{6} Hz (Correct Answer)**

(D) ○ 8 x 10^{-6} Hz

(E) ○ 1.054 x 10^{6} Hz

Question No.9 (Question Id - 43)

The first line in the rotational spectrum of carbonmonoxide appears at frequency 3.8424 cm^{-1}. The C - O bond length will be :

[N_A= 6.022 x 10^{23}/mol ; C = 3 x 10^{8} m/s)

(A) ○ 1.9 Å

(B) ○ 1.4 Å

(C) ○ 0.90 Å

(D) ○ **1.13 Å (Correct Answer)**

(E) ○ 1.23 Å

Question No.10 (Question Id - 33)

The CORRECT trend in ligand-to-metal charge transfer (LMCT) energies of the following metal tetraoxidoanions :

(A) ○ $VO_4^{3-} > CrO_4^{2-} > MnO_4^{-}$ and $ReO_4^{-} > TcO_4^{-} > MnO_4^{-}$ **(Correct Answer)**

(B) ○ $MnO_4^{-} > CrO_4^{2-} > VO_4^{3-}$ and $MnO_4^{-} > TcO_4^{-} > ReO_4^{-}$

(C) ○ $VO_4^{3-} > MnO_4^{-} > CrO_4^{2-}$ and $ReO_4^{-} > MnO_4^{-} > TcO_4^{-}$

(D) ○ $MnO_4^{-} > VO_4^{3-} > CrO_4^{2-}$ and $MnO_4^{-} > ReO_4^{-} > TcO_4^{-}$

(E) ○ $CrO_4^{2-} > MnO_4^{-} > VO_4^{3-}$ and $TcO_4^{-} > ReO_4^{-} > MnO_4^{-}$

Question No.11 (Question Id - 46)

For the reaction, Ag + $Fe(ClO_4)_3$ ⇋ $AgClO_4$ + $Fe(ClO_4)_2$, the equilibrium constant at 25°C is 0.60. The standard e.m.f. of a corresponding cell, Ag $|Ag^+|$ $|Fe^{++}$ $|Fe^{+++}Pt$ will be : [F = 96500 C mol^{-1} ;

R = 8.314 JK^{-1} mol^{-1}]

(A) ○ -1.1 x 10^{-3} volt
(B) ○ -11 x 10^{-3} volt
(C) ○ -0.13 volt
(D) ○ **-0.013 volt (Correct Answer)**
(E) ○ -0.013 x 10^{-3} volt

Question No.12 (Question Id - 30)

The Latimer diagram of chlorine in acidic solution is given below :

$$ClO_4^- \xrightarrow{+1.20\ V} ClO_3^- \xrightarrow{+1.18\ V}$$

$$HClO_2 \xrightarrow{+1.65\ V} HClO \xrightarrow{+1.67\ V}$$

$$Cl_2 \xrightarrow{+1.36\ V} Cl^-$$

Calculate the E^0 for the couple $HClO_2$ to Cl_2 in acidic medium.

(A) ○ +3.32 V
(B) ○ +1.11 V
(C) ○ +2.48 V
(D) ○ **+1.66 V (Correct Answer)**
(E) ○ +4.97 V

Question No.13 (Question Id - 47)

In a second order reaction of the type A + B → P, initially the concentrations of reactants were $[A]_0$ = 0.10 mol dm^{-3} and $[B]_0$ = 0.075 mol dm^{-3}. After 1 hr the concentration of B fell to [B] = 0.04 mol dm^{-3}. The rate constant k of the reaction will be :

(A) ○ 2.20 x 10^{-2} dm^3 mol^{-1} s^{-1}
(B) ○ 1.20 x 10^{-3} dm^3 mol^{-1} s^{-1}
(C) ○ **2.20 x 10^{-3} dm^3 mol^{-1} s^{-1} (Correct Answer)**
(D) ○ 2.20 x 10^{-3} dm^3 mol^{-1}
(E) ○ 1.20 x 10^{-2} dm^3 mol^{-1} s^{-1}

Question No.14 (Question Id - 39)

An electron is confined to an one-dimension box of length 1Å. The ground state energy will be : [h = 6.626 x 10^{-34} Js; m = 9.11 x 10^{-31}kg]

(A) ○ 6.024 x 10^{18} J
(B) ○ **6.024 x 10^{-18} J (Correct Answer)**
(C) ○ 6.024 x 10^{18} k.cal
(D) ○ 6.024 x 10^{-18} k.cal
(E) ○ 43.904 x 10^{+17} k.cal

Question No.15 (Question Id - 34)

The ground terms for Cr^{2+}, Cr^{3+} and Fe^{2+} are :

(A) ○ **^5D, ^4F and ^5D (Correct Answer)**
(B) ○ ^4F, ^5D and ^5D
(C) ○ ^3F, ^5D and ^5D
(D) ○ ^3F, ^6S and ^5D
(E) ○ ^3F, ^4F and ^5D

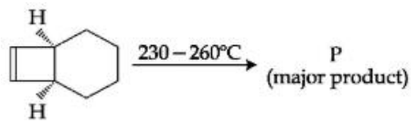
Question No.16 (Question Id - 19)

(S)–2–Phenylbutanal is reacted with Grignard reagent, methyl magnesium iodide.
The absolute configuration of the chiral carbons in the product of the above reaction is :

(A) ○ 1 S, 3 S
(B) ○ 1 R, 2 R
(C) ○ 1 S, 2 R

(D) ○ **1 S, 2 S (Correct Answer)**
(E) ○ 1 R, 2 S

Question No.17 (Question Id - 26)



The type of above pericyclic reaction, number of electrons involved in the reaction and the path(mode) followed by the reactions are :

(A) ○ **electrocyclic ring opening ; 4πe ; conrotatory. (Correct Answer)**
(B) ○ electrocyclic ring opening ; 2πe ; disrotatory.
(C) ○ .cycloaddition, 6πe, disrotatory
(D) ○ .sigmatropic, 2πe, (antara, antara)
(E) ○ .sigmatropic, 4πe, (supra, supra)

Question No.18 (Question Id - 48)

The characteristic conditions of the Langmuir isotherm are :

A. Adsorption cannot proceed beyond monolayer coverage

B. All sites are equivalent and the surface is uniform

C. Adsorption can proceed beyond monolayer coverage

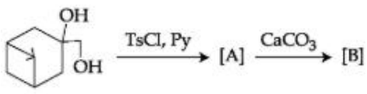
D. All sites are non-equivalent

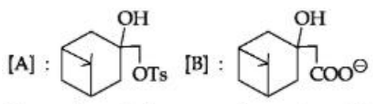
The correct option would be :

(A) ○ A and C
(B) ○ **A and B (Correct Answer)**
(C) ○ Only A
(D) ○ Only B
(E) ○ A, B and C

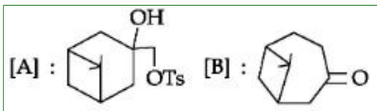
Question No.19 (Question Id - 21)

In the following reaction, predict the correct structures and identify the right statement :

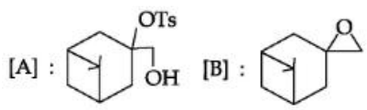


(A) ○


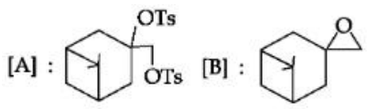
The carboxylate group is nucleophilically substituted.

(B) ○


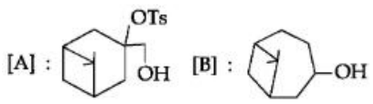
This is an example of a semipinacol rearrangement. **(Correct Answer)**

(C) ○


Selective tosylation of secondary alcohol and epoxide formation.

(D) ○


Tosylation with epoxide formation.

(E) ○


This is a Pinacol rearrangement.

Question No.20 (Question Id - 32)

Pick the correct answer from the following A straight chain silicone polymer is formed by :

(A) ○ Hydrolysis of CH_3SiCl_3 followed by condensation polymerization.

(B) ○ **Hydrolysis of $(CH_3)_2$ $SiCl_2$ followed by condensation polymerization. (Correct Answer)**

(C) ○ .Hydrolysis of $(CH_3)_3$ SiCl followed by condensation polymerization.

(D) ○ Hydrolysis of $(CH_3)_4$ Si followed by addition polymerization.

(E) ○ Hydrolysis of tetra ethyl ortho silicate followed by condensation polymerization.

Question No.21 (Question Id - 29)

Choose the **CORRECT** order of solubility of the following compounds in water in each set.

I. LiF, LiCl, LiBr

II. Ag_2O, Ag_2S, AgCl

(A) ○ LiBr > LiCl > LiF and AgCl > Ag_2S > Ag_2O

(B) ○ LiF > LiCl > LiBr and Ag_2O > Ag_2S > AgCl

(C) ○ **LiBr > LiCl > LiF and Ag_2O > AgCl > Ag_2S (Correct Answer)**

(D) ○ LiF > LiCl > LiBr and Ag_2S > Ag_2O > AgCl

(E) ○ LiF > LiCl > LiBr and AgCl > Ag_2O > Ag_2S

Question No.22 (Question Id - 44)

The difference in chemical potential between two regions of a system is +9.1 kJ mol^{-1}. By how much does the Gibbs energy change when 0.10 mmol of a substance is transfered from one region to the other ?

(A) ○ 1.9 x 10^{-3} kJ

(B) ○ 91.0 x 10^{-3} kJ

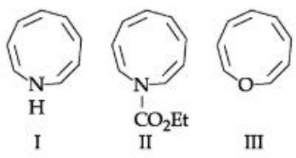
(C) ○ 19 x 10^{-3} kJ

(D) ○ 9.1 x 10^{-3} kJ

(E) ○ **0.91 x 10^{-3} kJ (Correct Answer)**

Question No.23 (Question Id - 17)

Predict the aromaticity, antiaromaticity or nonaromaticity in the following structures :



(A) ○ I : Antiaromatic ; II : Aromatic ; III : Aromatic

(B) ○ I : Aromatic ; II : Aromatic ; III : Aromatic

(C) ○ I : Nonaromatic ; II : Nonaromatic ; III : Nonaromatic

(D) ○ **I : Aromatic ; II : Nonaromatic ; III : Nonaromatic (Correct Answer)**

(E) ○ I : Antiaromatic ; II : Antiaromatic ; III : Antiaromatic

Question No.24 (Question Id - 45)

A sample consisting of 1.00 mol of perfect gas is expanded isothermally and reversibly at 20°C from 5 dm^3 to 15 dm^3. The q of the process is :

[R = 8.314 JK^{-1} mol^{-1}]

(A) ○ +0.982 kJ

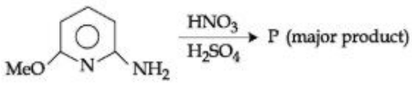
(B) ○ -0.982 kJ

(C) ○ -26.8 kJ

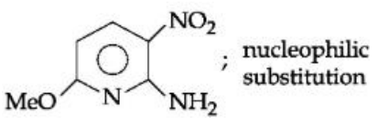
(D) ○ -2.68 kJ

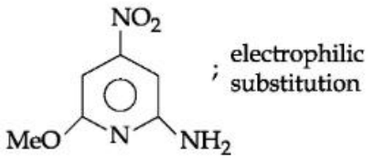
(E) ○ **+2.68 kJ (Correct Answer)**

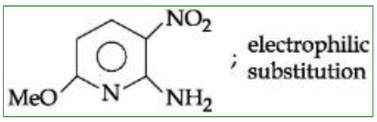
Question No.25 (Question Id - 23)

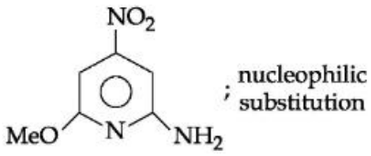


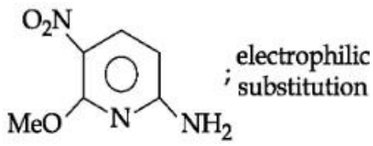
The structure of the product, P of above reaction and the type of reaction are :

(A) ○  ; nucleophilic substitution

(B) ○  ; electrophilic substitution

(C) ○  ; electrophilic substitution **(Correct Answer)**

(D) ○  ; nucleophilic substitution

(E) ○  ; electrophilic substitution

Question No.26 (Question Id - 31)

Out of the following reactions, which one will yield metal nitride ?

(A) ○ $NH_4Cl + NaNH_2$

(B) ○ $NH_3(aq) + NaOCl$

(C) ○ **$Ca(s) + NH_3(l)$ (Correct Answer)**

(D) ○ $NaNH_2 + NaNO_3$ at elevated temperatures

(E) ○ $NaNH_2 + N_2O$ at elevated temperatures

Question No.27 (Question Id - 36)

Arrange the following in the decreasing order of Rh–C bond lengths.

A. $Rh(CO)(Cl)(PPh_3)_2$

B. $Rh(CO)(Cl)(PEt_3)_2$

C. $Rh(CO)(Cl)[P(C_6F_5)_3]_2$

D. $Rh(CO)(Cl)(PMePh_2)_2$

Choose the **correct** answer from the options given below

(A) ○ B > D > A > C

(B) ○ A > D > B > C

(C) ○ D > A > B > C

(D) ○ C > B > A > D

(E) ○ **C > A > D > B (Correct Answer)**

Question No.28 (Question Id - 42)

Asymmetric top molecule among the following :

(A) ○ **CH_2CHCl (Correct Answer)**

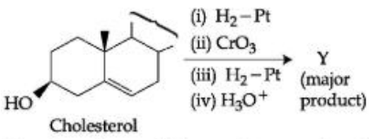
(B) ○ BCl_3

(C) ○ CH_3Cl

(D) ○ OCS

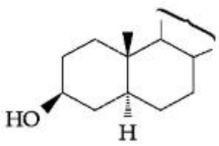
(E) ○ CCl_4

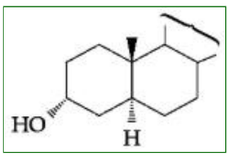
Question No.29 (Question Id - 20)

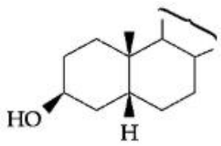


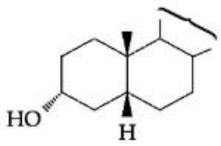
Cholesterol

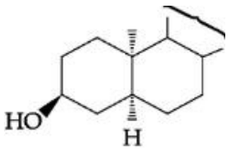
The structure of the major product, Y is :

(A) ○ 

(B) ○  **(Correct Answer)**

(C) ○ 

(D) ○ 

(E) ○ 

Question No.30 (Question Id - 28)

Considering the halides and oxides of elements from the periodic table, which statement is correct from the following :

(A) ○ Metals form basic oxides and high oxidation state halides of transition metals tend to be ionic.

(B) ○ **Metals form basic oxides and low oxidation state halides of transition metals tend to be ionic. (Correct Answer)**

(C) ○ Non-metals form acidic oxides and p-block halides are predominantly ionic.

(D) ○ Non-metals form basic oxides and p-block halides are predominantly covalent.

(E) ○ Metals form acidic oxides and s-block oxides are predominantly ionic.

Question No.31 (Question Id - 18)

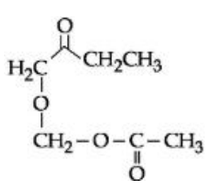
Elucidate the plausible molecular structure of a compound with molecular formula $C_7H_{12}O_4$, using following spectroscopic data :

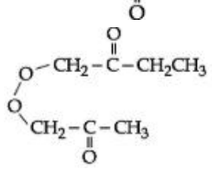
IR (cm^{-1}) : 2990 - 2880, 1735, 1150, 1035.

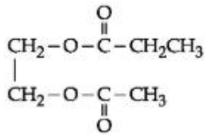
'H NMR : δ 1.28 (6 H, triplet)
δ 3.23 (4 H, quartet)
δ 4.16 (2 H, singlet)

Mass spectrum :

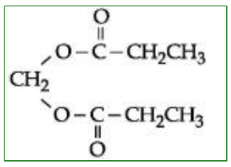
m/z : 161, 160, 133, 115, 43, 29

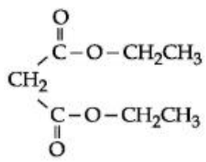
(A) ○ 

(B) ○ 

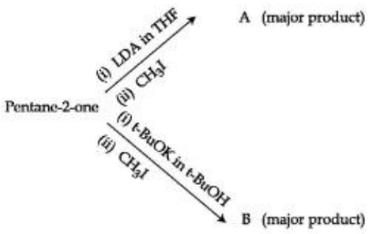
(C) ○ 

(D) ○

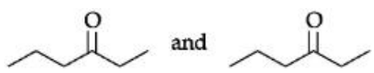

(Correct Answer)

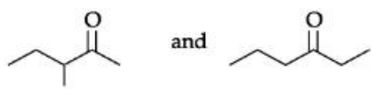
(E) ○ 

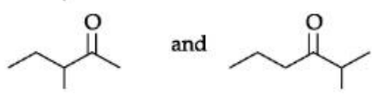
Question No.32 (Question Id - 24)

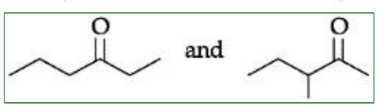


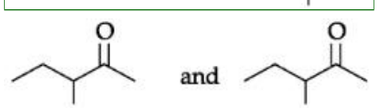
The structures of A and B are respectively.

(A) ○ 

(B) ○ 

(C) ○ 

(D) ○ 
(Correct Answer)

(E) ○ 

Question No.33 (Question Id - 50)

The fraction condensed (ρ) of a polymer by stepwise process with degree of polymerization < N > = 251 would be :

(A) ○ 9.96
(B) ○ **0.996 (Correct Answer)**
(C) ○ 1.96
(D) ○ 2.0
(E) ○ 0.0996

Question No.34 (Question Id - 37)

The bond order of the metal-metal bonds in $[Re_2Cl_4(P(C_2H_5)_3)_4]$, $[Re_2Cl_4(P(C_2H_5)_2\ Ph)_4]^{\oplus}$ and $[Re_2Cl_4(P(C_2H_5)Ph_2)_4]^{2+}$, respectively.

(A) ○ 4.0, 3.5 and 3.0
(B) ○ 3.5, 3.0 and 4.0
(C) ○ 4.0, 3.0 and 3.5
(D) ○ **3.0, 3.5 and 4.0 (Correct Answer)**
(E) ○ 3.0, 4.0 and 3.5

Question No.35 (Question Id - 35)

Among the following statements, which one characterizes the electronic absorption spectra of lanthanoid ions :

(A) ○ Sharp absorptions due to the strong interaction of the f-orbitals with the ligand vibration.
(B) ○ **Spectra that are independent of the ligand type and coordination number. (Correct Answer)**
(C) ○ Molar absorption coefficients are comparable with d-block elements.
(D) ○ Numerous absorptions due to orbital mixing.
(E) ○ Numerous absorptions due to the capability to show higher coordination number.

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