CHEMISTRY

Duration: Three Hours   rks: 100

Read the following instruction carefully

1.   This question paper contains 24 pages including blank pages for rough work. Please check all pag
      discrepancy, if any.

2.   Write your registration number, your, name and name of the examination centre at the specified locations on th
      half of the Optical Response Sheet (ORS).

3.   Using HB pencil, darken the appropriate bubble under each digit of your registration number and the letters
      corresponding to your paper code.

4.   All questions in this paper are of objective type.

5.   Questions must be answered on the ORS by darkening the appropriate bubble marked A, B, C, D) using HB pencil
      against the question number on the left hand side of the ORS. For each question darken the double of the correct answer.
      In case you wish to change an answer, erase the old answer completely. More than one answer bubbled against a question
      will be treated as an incorrect response.

6.   There are a total of 65 questions carrying 100 marks.

7.   Questions Q.1 – Q.25 will carry 1-mark each, and questions Q.26 – Q.55 will carry 2-marks each.

8.   Questions Q.48- Q.51 (2 pairs) are common data questions and question pairs (Q.52, Q.53) and (Q.54, Q.55) are linked
      answer questions. The answer to the second question of the linked answer questions depends on the answer to the first
      question of the pair. If the first question in the linked pair is wrongly answered or is un-attempted, then the answer to the
      second question in the pair will not be evaluated.

9.   Questions Q.56 - Q.65 belong to General Aptitude (GA). Questions Q.56 - Q.60 will carry 1-mark each, and questions
      Q.61 – Q.65 will carry 2-marks each. The GA questions will begin on a fresh page starting from page 15.

10.   Un-attempted questions will carry zero marks.

11.   Wrong answers will carry NEGATIVE marks. For Q.1–Q.25 and Q.56 – Q.60, 1/3 mark will be deducted for each wrong
      answer. For Q.26 – Q.51 and Q.61 - Q.65, 2/3 mark will be deducted for each wrong answer. The question pairs (Q.52,
      Q.53), and (Q.54, Q.55) are questions with linked answers. There will be negative marks only for wrong answer to the
      first question of the linked answer question pair i.e., for Q.52 and Q.54, 2/3 mark will be deducted for each wrong
      answer. There is no negative marking for Q.53 and Q.55.

12.   Calculator (without data connectivity) is allowed in the examination hall.

13.   Charts, graph sheets or tables are NOT allowed in the examination hall.

14.   Rough work can be done on the question paper itself. Additionally, blank pages are provided at the end of the question
   paper for rough work.

Some Useful Data

1. Physical Constants

(a) Planck Constant, $h = 6.626 \times 10^{-34} Js$

(b) Avogadro Number, $N = 6.023 \times 10^{23}$

(c) Speed of light $c = 3 \times 10^8 ms^{-1}$

(d) Gas constant $R = 8.314 \ JK^{-1} \ mole^{-1} = 2 \ cal \ K^{-1} mole^{-1}$

2. Atomic Numbers

|			
B	5	Mn	25
Mg	12	Fe	26
P	15	Co	27

Q.1-25 Carry one mark each

1. The Lewis acidity of BF_3 is less than BCl_3 even though fluorine is more el____ than chlorine. It is due to

   (a.) stronger 2p(B)-2p(F) σ-bonding

   (b.) stronger 2p(B)-3p(F) π-bonding

   (c.) stronger 2p(B)-2p(Cl) σ-bonding

   (d.) stronger 2p(B)-3p(Cl) π-bonding

2. Pyroxenes are a class of silicate minerals, which exhibit a polymeric chain structure, as shown below.

   = Silicon   O = Oxygen
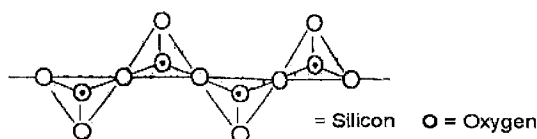
   Its simplest repeat unit is

   (a.) $[SiO_4]^{4-}$

   (b.) $[SiO_3]^{2-}$

   (c.) $[Si_2O_7]^{6-}$

   (d.) $[Si_4O_{11}]^{6-}$

3. Among the following pentachlorides the one which does not exist due to the 'inert-pair effect' is

   (a.) PCl_5

   (b.) $BiCl_5$

   (c.) $SbCl_5$

   (d.) $AsCl_5$

4. Band theory predicts that magnesium is an insulator. However, in practice it acts as a conductor due to

   (a.) presence of filled 3s orbital

   (b.) overlap of filled 2p and filled 3s orbital

   (c.) overlap of filled 3s and empty 3p orbital

   (d.) presence of unfilled 3p orbital

5. The number of 'framework electron pairs' present in the borane clustr $[B_{12}H_{12}]^{2-}$ is

   (a.) 10

   (b.) 11

   (c.) 12

   (d.) 13

(a.) between 1 and 2

(b.) less than 1

(c.) unaltered

(d.) greater than 2

7. Among the following pair of metal ions present in Nature, the first one functions as transfer agent and the second one catalyzes the hydrolysis reactions The correct pair is

(a.) Fe and Zn

(b.) Mg and Fe

(c.) Co and Mo

(d.) Ca and Cu

8. Structurally nickellocene is similar to ferrocene. Nickellocene attains stability due to the formation of

(a.) a monocation

(b.) a dication

(c.) a monoanion

(d.) a dianion

9. The absolute configurations for compounds X and Y, respectively, are
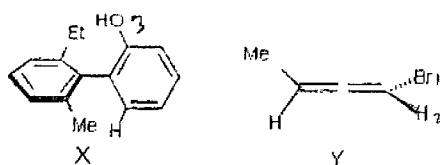

(a.) R, S

(b.) S, R

(c.) R, R

(d.) S, S

10. In the reaction

the major product [X] is

(a.)

(b.)

CH₃
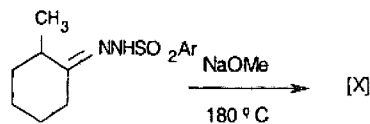
(c.)
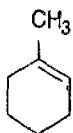
(d.)

11. Among the following, a pair of resolvable configurational enantiomers is given by

(a.) cis-1,2-dimethylcycloheaxne

(b.) cis-1,3-dimethylcyclohexane

(c.) cis-1,4-dimethylcyclohexane

(d.) trans-1,3-dimethylcyclohexane

12. In the reaction
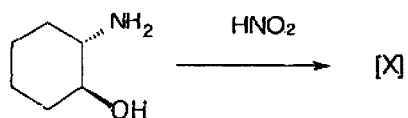
the major product [X] is

(a.)
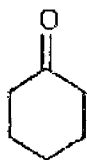
(b.)
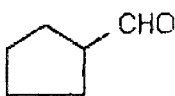
(c.)
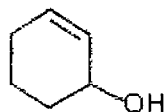
(d.)
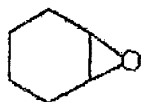
13. The decreasing order of isoelectric point for the following α-amino acids is

Lysin   Alanine   Gultamic acid

(b.) II > I > III

(c.) III > I > II

(d.) I > III > II

14. Te decreasing order of the reactivity of the following compounds towards electrophi
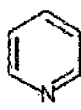
I   II   III

(a.) II > I > III

(b.) II > III > I

(c.) III > I > II

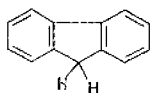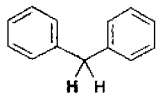(d.) I > II > III

15. In the reaction
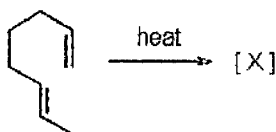
the major product [X] is

(a.)

(b.)
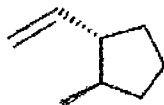
(c.)

(d.)
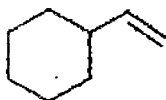
16. The decreasing order of acidity of the marked **H** of the following molecules is
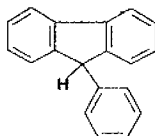
(c.) III > II > I

(d.) II > I > III

17. The decreasing order of nucleophilicity for the following anions is

$CH_3CO_2^-$, CH_3O^-, $C_6H_5O^-$, NO_3^-

(a.) $CH_3CO_2^- > CH_3O^- > C_6H_5O^- > NO_3^-$

(b.) $CH_3O^- > NO_3^- > C_6H_5O^- > CH_3CO_2^-$

(c.) $CH_3O^- > C_6H_5O^- > CH_3CO_2^- > NO_3^-$

(d.) $C_6H_5O^- > CH_3O^- > NO_3^- > CH_3CO_2^-$

18. The molar entropy of crystalline CO at absolute zero is

(a.) Zero

(b.) $-R \ln 2$

(c.) $R \ln 2$

(d.) $2 R \ln 2$

19. For an ideal gas

(a.) $\left(\partial P / \partial T\right)_V \left(\partial T / \partial V\right)_P \left(\partial V / \partial P\right)_T = 0$

(b.) $\left(\partial P / \partial T\right)_V \left(\partial T / \partial V\right)_P \left(\partial V / \partial P\right)_T = -1$

(c.) $\left(\partial P / \partial T\right)_V \left(\partial T / \partial V\right)_P \left(\partial V / \partial P\right)_T = +1$

(d.) $\left(\partial P / \partial T\right)_V \left(\partial T / \partial V\right)_P \left(\partial V / \partial P\right)_T = +2$

20. Among W (work), Q (heat), U (internal energy) and S (entropy)

(a.) W and U are path function but Q and S are state functions

(b.) W and S are path functions but Q and U are State functions

(c.) S and U are path functions but Q and W are state functions

(d.) W and Q are path functions but U and S are state functions

21. For eigen function $\psi_1 = \sqrt{\dfrac{1}{b}} \sin\left(\dfrac{\pi x}{b}\right)$ and $\psi_2 = \sqrt{\dfrac{2}{b}} \sin\left(\dfrac{2\pi x}{b}\right)$ of particle in a 1-D box of length $b\left(0 \leq x \leq b\right)$

(a.) ψ_1 is normalized and orthogonal to ψ_2

(b.) ψ_1 is normalized but not orthogonal to ψ_2

(c.) ψ_2 is normalized and orthogonal to ψ_1

(d.) ψ_2 is neither normalized nor orthogonal to ψ_1

22. The bond order of C_2 molecule is

(c.) 2

(d.) 3

23.   Sulfur can exist in four phases. The possible number of triple point is

(a.) 1

(b.) 2

(c.) 3

(d.) 4

24.   The standard reduction potentials at 298 K for single electrons are given below:

Electrode   Electrode Potential (volt)

Mg^{2+}/Mg -2.34

Zn^{2+}/Zn -0.76

Fe^{2+}/Fe-0.44

From this we can infer that

(a.) Zn can reduce both Mg^{2+} and Fe^{2+}

(b.) Fe can reduce both Mg^{2+} and Zn^{2+}

(c.) Mg can reduce both Zn^{2+} and Fe^{2+}

(d.) Mg can reduce Zn^{2+} and Fe^{2+}

25.   For the pair of reactions given below

$i)$ $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$ii)$ $\dfrac{1}{2}N_2(g) + \dfrac{3}{2}H_2(g) \rightleftharpoons NH_3(g)$
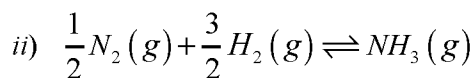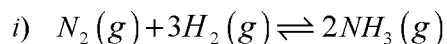
if at a particular temperature, K_{P1} and K_{P2} are the equilibrium constants for reaction i) and ii) respectively then,

(a.) $K_{P1} = 2K_{P2}$

(b.) $K_{P1} = K_{P2}^2$

(c.) $2K_{P1} = K_{P2}$

(d.) $K_{P1}^2 = K_{P2}$

Q.26-55 Carry two marks each

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26.   According to VSEPR model, the shape of $[XeOF_5]^-$ is

(a.) octahedral

27. The number of unpaired electron(s) present in the species $[Fe(H_2O)_5(NO)]$ is formed during 'brown ring test' is

(a.) 2

(b.) 3

(c.) 4

(d.) 5

28. Fe_3O_4 and Co_3O_4 are metal oxides having spinel structure. Considering their CFSEs, the correct statement regarding their structure is

(a.) both have normal spinel structure

(b.) both have inverse spinel structure

(c.) Fe_3O_4 has normal and Co_3O_4 has inverse spinel structure

(d.) Fe_3O_4 has inverse and Co_3O_4 has normal spinel structure

29. The mechanism of the reaction between $[Fe(CN)_6]^{4-}$ and $[Fe(bpy)_3]^{3+}$ (bpy = 2,2-bipyridine) is

(a.) outer-sphere electron-transfer

(b.) inner-sphere electron-transfer

(c.) self-exchange reaction

(d.) ligand-exchange followed by electron-transfer

30. The d-d absorption band of $[Fe(H_2O)_6]^{2+}$ is split due to

(a.) presence of octahedral geometry

(b.) static Jahn-Teller distortion

(c.) dynamic Jahn-Teller distortion

(d.) presence of trigonal bipyramidal geometry

31. The crystal-field symbol for the ground-state of $[Mn(CN)_6]^{4-}$ is

(a.) $^2T_{2g}$

(b.) $^1A_{1g}$

(c.) ^5E_g

(d.) $^6A_{1g}$

32. In the following reactions:
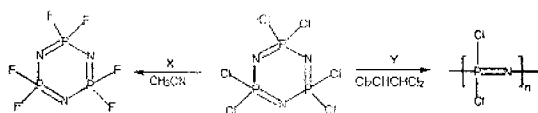
the reagent/conditions X and Y are

(a.) X = BF_3 ; Y = heating at 1250°C

(b.) X = NaF ; Y = heating at 250°C

(c.) X=NH_4 ; Y=HCl

33. $[CoCl_4]^{2-}$ is a blue coloured complex. Controled-treatment of this ~~compl~~ ... ~~wat~~er generates two isomeric light pink coloured complexes of composition $[Co(H_2O)_4Cl_2]$.

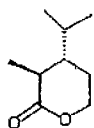Identify the correct point groups for $[CoCl_4]^{2-}$ and two isomeric complexes [Co...

(a.) D_{4h} and (C_{2v} and C_{2h})

(b.) T_d and C_{2v} and D_{4h})

(c.) D_{4h} and (C_{2v}, and D_{4h})

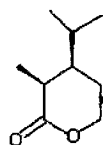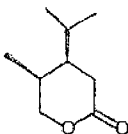(d.) T_d and (C_{2v} and C_{4v})

34. In the reaction
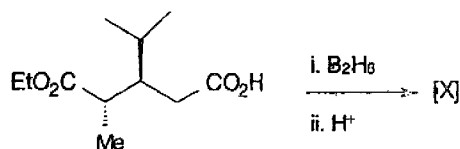
the major product [X] is

(a.)

(b.)

(c.)

(d.)
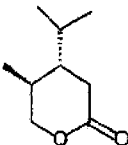
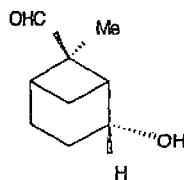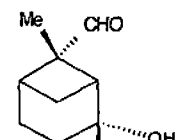
35. In the reaction
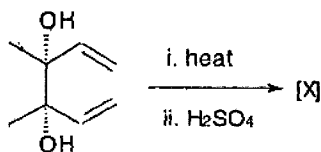
the major product [X] is

(a.)

(b.)
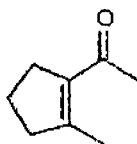
(c.)
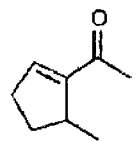
(d.)
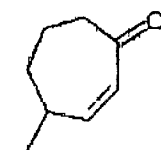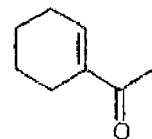
36. In the following reaction sequence

Me Me
i. NOCl/Py
ii. light
⟶ [X]
iii. hydrolysis
···OH
H

the major product [X] is

(a.)

HOOC Me

···OH
H

(b.)

OHC Me

···OH
H

(c.)

Me CHO

····OH
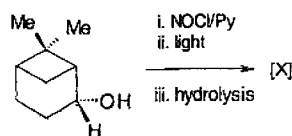
37. In the reactions

[Y] ←── HNO₃ ── [structure] ── mCPBA ──→ [X]

the major product [X] and [Y], respectively, are

(a.)

(b.)

(c.)

(d.)

38. In the reaction

the major product [X] is

(a.)

(b.)

(c.)

(d.)
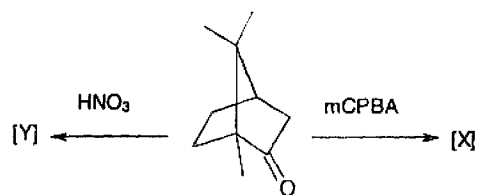

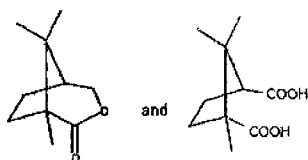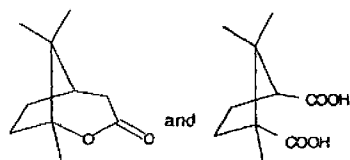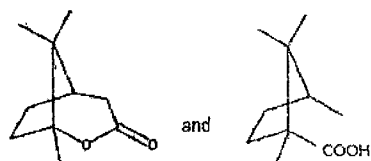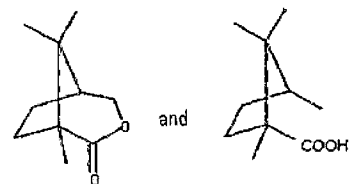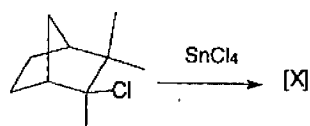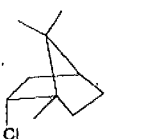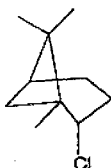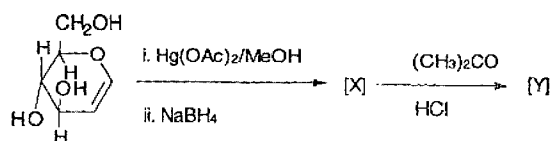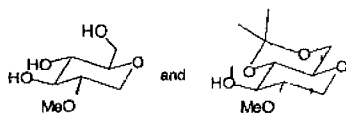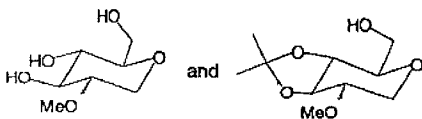
39. In the reaction sequence

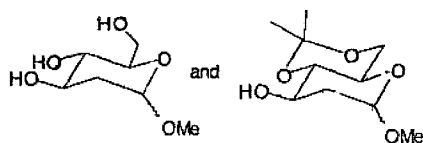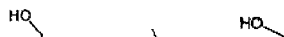the major product [X] and [Y], respectively, are

(a.)

(b.)

(c.)

(d.)

40. The change in entropy when two moles of Argon gas are heated at con... ...e from 300 K to 500 K is

(a.) -12.74 J K^{-1} mole^{-1}

(b.) -6.37 J K^{-1} mole^{-1}

(c.) 6.37 J K^{-1} mole^{-1}

(d.) 12.74 J K^{-1} mole^{-1}

41. At any temperature T, the fugacity coefficient (γ) is given by

$$\ln \gamma = \int_0^P \frac{Z-1}{P'} dP'$$

where Z is the compressibility factor. The fugacity coefficient of a real gas governed by equation of state $P(V - b) = RT$ with b a constant is given by

(a.) $\dfrac{RT}{bP}$

(b.) $e^{\frac{RT}{bP}}$

(c.) $\dfrac{bP}{RT}$

(d.) $e^{\frac{bP}{RT}}$

42. The specific rate constant of decomposition of a compound is represented by

$$\ln k = 5.0 - \frac{12000}{T}$$

The activation energy of decomposition for this compound at 30b K is

(a.) 24 kcal/mole

(b.) 12 kcal/mole

(c.) 24 cal/mole

(d.) 12 cal/mole

43. The commutator $\left[x^3, p_x \right]$ is equal to

(a.) $-\dfrac{3hx^2}{2\pi i}$

(b.) $\dfrac{hx}{2\pi i}$

(c.) $\dfrac{hx^2}{2\pi i}$

$\dfrac{3hx^2}{}$

44. An electron of mass '*m*' is confined to a one dimensional box of length ~~b~~ makes a radiative transition from second excited state to the ground state, the frequency of the ~~light emitted~~ itted is

(a.) $\dfrac{9h}{8mb^2}$

(b.) $\dfrac{3h}{8mb^2}$

(c.) $\dfrac{h}{mb^2}$

(d.) $\dfrac{2h}{mb^2}$

45. The point group of ClF_3 molecule and its corresponding number of irreducible representations are respectively

(a.) C_{3v} and 4

(b.) C_{2v} and 4

(c.) C_{3v} and 3

(d.) C_{2v} and 3

46. The most populated rational state for HCl (B= 8.5 cm^{-1}) at 300 K is

(a.) 2

(b.) 3

(c.) 5

(d.) 7

47. The ratio of life times of two states that give rise to line widths of 1.0 cm^{-1} and 0.2 cm^{-1} respectively is

(a.) 1 : 2

(b.) 1 : 5

(c.) 2 : 1

(d.) 5 : 1

Common Data Questions

Common Data for Questions 48 and 49:

A six-coordinate transition metal complex is ESR and Mossbauer active. The effective magnetic moment of this complex is ~5.9 B.M.

48. The metal-ion along with its oxidation state and the number of unpaired electron present are

(c.) Fe(III) and 1

(d.) Fe(III) and 5

49. The complex is

(a.) $[Mn(H_2O)_6]^{2+}$

(b.) $[Fe(CN)_6]^{3-}$

(c.) $[Fe(H_2O)_6]^{2+}$

(d.) $[Fe(H_2O)_6]^{3+}$

Common Data for Questions 50 and 51:

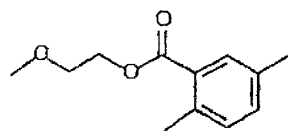An organic compound [X] ($C_{12}H_{16}O_3$) exhibits the following spectral data

IR: ~1720 cm^{-1}

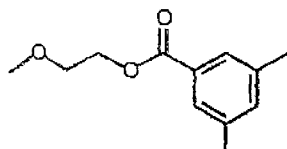^{1}H NMR: 2.35 (s, 6H), 3.30 (s, 3H), 3.83 (t, 2H), 4.42 (t, 2H), 7.07 (s, 1H), 7.58 (s, 1H

The compound [X] with an excess of MeMgBr gives a 1 : 1 mixture of compound [Y] and [Z]. The compound [Z] exhibits the following ^{1}H NMR data: 2.0 (bs, 1H), 3.30 (s, 3H), 3.56 (t, 2H), 3.70 (t, 2H)
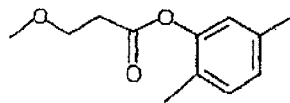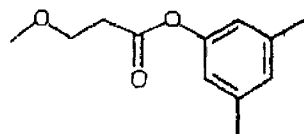
50. The compound [X] is

(a.)

(b.)

(c.)

(d.)

51. The compound [Y] is

(a.)

OH

(b.)

OH and O OH

(c.)

HO and O OH

(d.)

HO and O OH
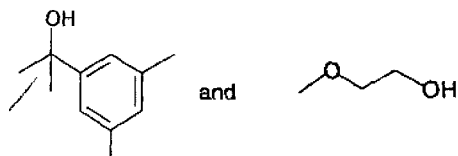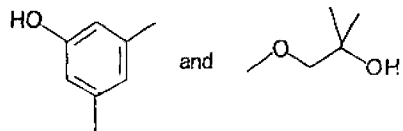
Linked Answer Questions

Statement for Linked Answer Questions 52 and 53:

In the reaction sequence

Ph
| CHO
H₃C—H

$\xrightarrow[\text{H}_3\text{O}^+]{\text{MeMgBr}}$ [X] (major) + [Y] (minor)

[X] $\xrightarrow[\text{ii. NaOEt/EtOH}]{\text{i. TsCl/Py}}$ [Z]

52.   The compound [X] is

(a.)

Ph
H——CH₃
H₃C——H
OH

(b.)

Ph
H₃C——H
H——CH₃
OH

(c.)

Ph
H_3C —|— H
H_3C —|— H
OH

(d.)

CH_3
Ph —|— H
HO —|— H
CH_3

53. The compound [Z] is

(a.)
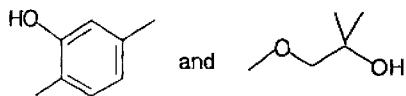
Me
Me
EtO
H
Ph
H

(b.)

Me
EtO
Me
H
Ph
H

(c.)

Me
Me
Ph
H

(d.)

Ph
Mel
Me
H
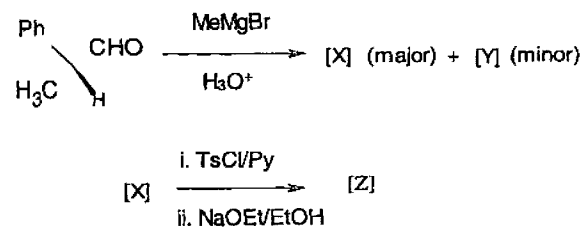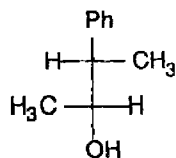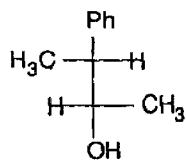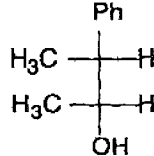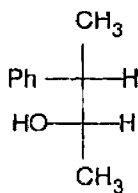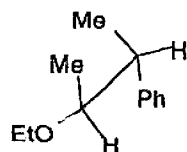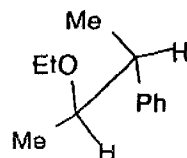
Statement for Linked Answer Questions 54 and 55:

In the μ vs. T diagram for different phases of the same substance at one atmospheric pressure, the lines A, B and C compound to

54. Based on the above diagram:

(a.) A represents the change in chemical potential as a function of temperature for the solid phase, B for the liquid and C for the gas

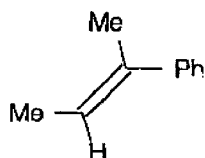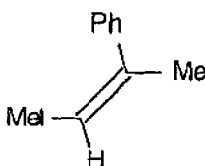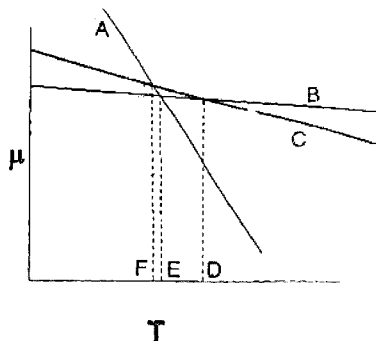(b.) A represents the change in chemical potential as a function of temperature for the liquid phase, B for the gas and C for the solid

(c.) A represents the change in chemical potential as a function of temperature for the gas phase, B for the liquid and C for the solid

(d.) A represents the change in chemical potential as a function of temperature for the gas phase, B for solid and C for the liquid.

55. From the same diagram

(a.) D represents boiling point, E sublimation point and F melting point

(b.) B represents boiling point, D sublimation point and F melting point

(c.) B represents melting point, F sublimation point and D boiling point

(d.) D represents melting point, F boiling point and B sublimation point

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General Aptitude (GA) Questions

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56. 25 persons are in a room. 15 of them play hockey, 17 of them play football and 10 of them play both hockey and football. Then the number of persons playing either hockey nor football is :

(a.) 2

(b.) 17

(c.) 13

(d.) 3

57. Choose the most appropriate word from the options given below to complete the following sentence:

If we manage to _____ our natural resources, we would leave a better planet or our children.

(a.) uphold

(b.) restrain

58. The question below consists of a pair of related words followed by ~~four~~ words. Select the pair that best expresses the relation in the original pair.

Unemployed : Worker

(a.) fallow : land

(b.) unaware : sleeper

(c.) wit : jester

(d.) renovated : house

59. Which of the following options is the closest in meaning to the word below:

Circuitous

(a.) cyclic

(b.) indirect

(c.) confusing

(d.) crooked

60. Choose the most' appropriate word from the options given below to complete the following sentence:

His rather casual remarks on politics _____ his lack of seriousness about the subject.

(a.) masked

(b.) belied

(c.) betrayed

(d.) suppressed

Q.61-Q.65 carry two marks each:

61. Hari (H), Gita (G), Irfan (I) and Saira (S) are siblings (*i.e.* brothers and sisters). All were born on 1st January. The age difference between any two successive siblings (that is born one after another is less than 3 years. Given the following facts:

    i.   Hari's age + Gita's age > Irfan's age + Saira's age

    ii. The age difference between Gita and Saira is 1 year. However, Gita is not the oldest and Saira is not the youngest

    iii. There are no twins.

    In what order were they born (oldest first)?

    (a.) HSIG

    (b.) SGHI

    (c.) IGSH

    (d.) IHSG

(a.) 20 days

(b.) 18 days

(c.) 16 days

(d.) 15 days

63. **Modern warfare has changed from large scale clashes of armies to suppression populations. Chemical agents that do their work silently appear to be suited to such and regretfully, there exist people in military establishments who think that chemical are useful tools for their cause.**

Which of the following statements best sums up the meaning of the above passage:

(a.) Modern warfare has resulted in civil strife

(b.) Chemical agents are useful in modern warfare

(c.) Use of chemical agents in warfare would be undesirable

(d.) People in military establishments like to use chemical agents in war.

64. Given digits 2, 2, 3, 3, 3, 4, 4, 4, 4 how many distinct 4 digit numbers greater than 3000 can be formed?

(a.) 50

(b.) 51

(c.) 52

(d.) 54

65. If 137 + 276 = 435 how much is 731 + 672?

(a.) 534

(b.) 1403

(c.) 1623

(d.) 1513