ENTRANCE EXAMINATION – 2017
Ph. D. Chemistry

TIME: 2 HOURS

HALL TICKET NUMBER: 

MAXIMUM MARKS: 80

INSTRUCTIONS

1. Write your HALL TICKET NUMBER in the space provided above and also on the OMR ANSWER SHEET given to you.

2. Make sure that pages numbered from 1 - 21 are present (excluding 5 pages assigned for rough work).

3. There are eighty (80) multiple choice questions in this paper (20 in Part-A and 60 in Part-B). You are required to answer all questions of Part-A and a maximum of 20 questions of Part-B. If more than the required numbers of questions are answered, only the first 20 questions of Part-B will be evaluated.


5. There is negative marking for both Part-A and Part-B. Each wrong answer carries -0.66 mark.

6. Answers are to be marked on the OMR answer sheet following the instructions provided on it.

7. Hand over the OMR answer sheet to the invigilator at the end of the examination.

8. In case of a tie, the marks obtained in the first 20 questions (Part-A) will be used to determine the order of merit.

9. No additional sheets will be provided. Rough work can be done in the space provided at the end of the booklet.

10. Calculators are allowed. Cell phones are not allowed.

11. Useful constants are provided at the beginning of Part-A in the question paper.

12. OMR without hall ticket number will not be evaluated and University shall not be held responsible.
Useful Constants:

- Rydberg constant = 109737 cm⁻¹;
- Faraday constant = 96500 C;
- Planck constant = 6.625 x 10⁻³⁴ J s;
- Speed of light = 2.998 x 10⁸ m s⁻¹;
- Boltzmann constant = 1.380 x 10⁻²³ J K⁻¹;
- Gas constant = 8.314 J K⁻¹ mol⁻¹ = 0.082 L atm K⁻¹ mol⁻¹ = 1.987 cal K⁻¹ mol⁻¹;
- Mass of electron = 9.109 x 10⁻³¹ kg;
- Mass of proton = 1.672 x 10⁻²⁷ kg;
- Charge of electron = 1.6 x 10⁻¹⁹ C;
- 1 D = 3.336 x 10⁻¹⁰ C m;
- 1 bar = 10⁵ N m⁻²;
- RT/F (at 298.15 K) = 0.0257 V.

Part-A

1. 500 mL of an aqueous solution of AgCl contains 0.10 mg of Ag⁺ ions. The concentration of Cl⁻ ions in the solution is $K_{sp} (AgCl) = 1.0 \times 10^{-10}$ M²; atomic weight of Ag = 107.9 g/mol

   [A] $1.0 \times 10^{-10}$ M
   [B] $5.4 \times 10^{-5}$ M
   [C] $9.2 \times 10^{-4}$ M
   [D] $1.0 \times 10^{-4}$ M

2. 34.76 mL of KMnO₄ solution of unknown strength is needed for the titration of 62.50 mL of 0.20 M Na₂C₂O₄ solution. The normality of KMnO₄ solution is

   [A] 0.36
   [B] 0.56
   [C] 0.72
   [D] 0.18

3. An icosahedron can be described as bicapped

   [A] hexagonal antiprism
   [B] pentagonal prism
   [C] pentagonal antiprism
   [D] hexagonal prism
4. Which of the following remains unchanged in the geometrical conversion?

![Icosahedron and Dodecahedron]

[A] Number of vertices  [B] Number of edges
[C] Number of faces  [D] All of the above

5. Among the following set of quantum numbers, which one represents an electron with highest energy?

[A] n=3, l=0, m₁=0, mₛ=-1/2  [B] n=3, l=1, m₁=-1, mₛ=-1/2
[C] n=4, l=0, m₁=0, mₛ=+1/2  [D] n=3, l=2, m₁=0, mₛ=+1/2

6. For which of the following species is the color not due to a d-d transition? VO²⁺, CrO₄²⁻, MnO₄²⁻, MnO₄⁻

[A] MnO₄²⁻ and MnO₄⁻  [B] VO²⁺ and MnO₄⁻
[C] CrO₄²⁻ and MnO₄⁻  [D] MnO₄²⁻ and CrO₄²⁻

7. When 2-butyne is subjected to hydrogenation with Pd-BaSO₄/quinolone, the product formed is:

[A] n-butane  [B] cis-2-butene
[C] trans-2-butene  [D] 1-butene
8. Identify the meso compound from the following:

   ![Meso Compounds]

   [A] [B] [C] [D]

9. The metal complex that is generally used in the tanning of leather is that of

   [A] Rhodium   [B] Chromium
   [C] Ruthenium   [D] Tungsten

10. Who won the Nobel prize for outstanding contribution to the chemistry of carbocations?


11. Identify the most appropriate rule in an asymmetric Grignard reaction of prochiral ketone:

    [A] Hückel rule   [B] Cram’s rule
    [C] Baldwin’s rule   [D] Hoffmann’s rule

12. Arrange the following molecules in the increasing order of C-H bond dissociation energy (kJ mol\(^{-1}\)).

    ![Molecules]

    (I) (II) (III) (IV)

    [A] IV<II<III<I   [B] I<III<IV<II
    [C] III<II<IV<I   [D] II<IV<I<III
13. The property of two systems that should be equalized for chemical equilibrium is

[A] entropy  \[\text{B} \] chemical composition

[C] chemical potential  \[\text{D} \] enthalpy

14. A molecule will be chiral only if it lacks:

[A] center of inversion  \[\text{B} \] reflection plane

[C] proper axis of rotation  \[\text{D} \] improper axis of rotation

15. The average momentum of a particle confined in a one-dimensional box of length \( L \) is

[A] 0  \[\text{B} \] \( \frac{n \pi h}{L} \)

[C] \( \frac{n^2 \pi^2 h^2}{4L^2} \)  \[\text{D} \] \( \frac{n^2 \pi^2 h^2}{4L^2} \)

16. A molecule that will show pure rotational spectrum is

[A] ethylene  \[\text{B} \] allene

[C] cis butadiene  \[\text{D} \] trans butadiene

17. The molecule with the largest rotational partition function at a given temperature, among the following is

[A] \( \text{H} - \text{C} \equiv \text{C} - \text{H} \)  \[\text{B} \] \( \text{CH}_3 - \text{C} \equiv \text{C} - \text{H} \)

[C] \( \text{CH}_3 - \text{C} \equiv \text{C} - \text{CH}_3 \)  \[\text{D} \] \( \text{Cl} - \text{C} \equiv \text{C} - \text{Cl} \)

18. The mean value of a set of numbers can be given as arithmetic mean (AM), geometric mean (GM) and harmonic mean (HM). Which of the following correctly describes the relation among these three?

[A] \( \text{AM} \leq \text{GM} \leq \text{HM} \)  \[\text{B} \] \( \text{GM} \leq \text{AM} \leq \text{HM} \)

[C] \( \text{HM} \leq \text{GM} \leq \text{AM} \)  \[\text{D} \] \( \text{HM} \leq \text{AM} \leq \text{GM} \)
19. A 230 m long train running at a speed of 50 km h\(^{-1}\) crosses another train running in the opposite direction at a speed of 50 km h\(^{-1}\) in 18 seconds. What is the length of the other train?

[A] 270 m  [B] 330 m  
[C] 250 m  [D] 230 m

20. The most important peaks in the electron impact mass spectrum of 2-pentanone will be at the m/z values of:

(A) 15, 29, 43, 58, 71, 86  
(B) 15, 29, 43, 57, 71, 86  
(C) 15, 29, 43, 71, 86  
(D) 15, 29, 57, 71, 86

**Part-B**

21. The resistance of 0.2 M solution of an electrolyte is 50 Ω and its specific conductance is 1.3 S m\(^{-1}\). If the resistance of the 0.4 M solution of the same electrolyte is 260 Ω, the difference in molar conductance of the two solutions is

[A] 5.875 \times 10^{-3} S m^2 mol^{-1}  
[B] 0.25 \times 10^{-3} S m^2 mol^{-1}  
[C] 6.25 \times 10^{-4} S m^2 mol^{-1}  
[D] 6.5 \times 10^{-4} S m^2 mol^{-1}

22. The metal-metal bond orders in [Re\(_2\)Cl\(_8\)]\(^{4+}\), [Re\(_2\)Cl\(_8\)]\(^{2-}\) and [Re\(_2\)Cl\(_6\)(PPh\(_3\))\(_2\)] are respectively

[A] 3, 4 and 4  
[B] 4, 3 and 2  
[C] 3, 2 and 2  
[D] 2, 3 and 4

23. Which of the molecules/ions has/have an S\(_4\) axis?

[A] PF\(_5\) and SO\(_4\)\(^{2-}\)  
[B] SF\(_4\) and SO\(_4\)\(^{2-}\)  
[C] SO\(_4\)\(^{2-}\) only  
[D] BF\(_3\) and SF\(_4\)
24. Choose the correct statement/s in connection with iodometric titrations in the presence of excess iodide solution:
   (i) The reactive species in these titrations is the triiodide anion
   (ii) Starch solution is added in the beginning of the titration as an indicator.
   (iii) The titration can be performed in the presence of stannous chloride.

   [A] (i) and (ii)  [B] (ii) and (iii)
   [C] (i) and (iii)  [D] (i) only

25. The ground state term symbol for Ho³⁺ (Atomic number = 67) ion is

   [A] 5I⁸  [B] 5H₁₅/₂
   [C] 4I₁₅/₂  [D] 2F₇/₂

26. The hapticities (i.e. ‘n’ value in ηⁿ) of the Cp⁻ (cyclopentadienide) rings in the 18-electron compound Cp₂W(CO)₂ are

   [A] 1, 3  [B] 3, 5
   [C] 2, 4  [D] 4, 5

27. The origin of yellow-orange color of [Co(en)₃]³⁺ (en = 1, 2-diaminoethane) is

   [A] ligand-field transition  [B] ligand-to-metal charge transfer
   [C] metal-to-ligand charge transfer  [D] intraligand transition

28. The number of hydrophilic and hydrophobic channels in Ferritin are respectively

   [A] 8, 8  [B] 6, 6
   [C] 8, 6  [D] 6, 8
29. The half-life of $^{32}\text{P}$ is 14.2 days. How long would it take for the disintegration to reduce from 42,000 per minute to 500 per minute?

[A] 90.8 days  
[C] 14.19 days

[B] 39.42 days  
[D] 1.33 days

30. Formulae for ortho-, pyro-, chain-, and double chain silicates are respectively

[A] $[\text{SiO}_4]^{4-}$, $[\text{Si}_2\text{O}_7]^{6-}$, $[\text{Si}_3\text{O}_8]^{5-}$, $[\text{Si}_4\text{O}_{11}]^{6-}$  
[B] $[\text{SiO}_4]^{4-}$, $[\text{Si}_2\text{O}_7]^{6-}$, $[\text{Si}_3\text{O}_8]^{5-}$, $[\text{Si}_4\text{O}_{11}]^{6-}$

[C] $[\text{SiO}_4]^{4-}$, $[\text{Si}_2\text{O}_7]^{6-}$, $[\text{Si}_3\text{O}_8]^{5-}$, $[\text{Si}_4\text{O}_{11}]^{6-}$  
[D] $[\text{SiO}_4]^{4-}$, $[\text{Si}_2\text{O}_7]^{6-}$, $[\text{Si}_3\text{O}_8]^{5-}$, $[\text{Si}_4\text{O}_{11}]^{6-}$

31. The intercept of the Tafel plot ($\eta$ vs. log (i)) is used to estimate

[A] Transfer coefficient  
[C] Exchange current density

[B] Rate of the reaction  
[D] Kinetic current density

32. The metalloenzymes/metalloproteins, associated with the metals Fe, Zn, Mo and Cu are

[A] hemocyanin, ferritin, sulfite oxidase and carboxypeptidase respectively.

[B] ferritin, carbonic anhydrase, sulfite oxidase and hemocyanin respectively.

[C] ferritin, aldehyde oxidase, nitrogenase and vitamin B12 respectively.

[D] hemoglobin, sulfite oxidase, carbonic anhydrase and blue protein respectively

33. The total number of lines observed in the ESR spectrum of naphthalenide ion (I = 1/2 for proton) is

[A] 5  
[C] 9

[B] 25  
[D] 15
34. Which of the following pair of complex ions are expected to undergo tetragonal distortion?

[A] [Cr(H₂O)₆]²⁺ and [Cu(NH₃)₆]²⁺  [B] [Fe(CN)₆]⁴⁻ and [MnF₆]⁴⁺
[C] [Cr(H₂O)₆]²⁺ and [Fe(CN)₆]⁴⁻  [D] [MnF₆]⁴⁻ and [Cu(NH₃)₆]²⁺

35. 0.5582 g of iron ore is converted into Fe₂O₃. Weight of Fe₂O₃ obtained is 0.2481 g. The percentage of iron (Fe) in the ore is (Atomic weight of Fe = 55.85 g/mol)

[A] 31.09  [B] 7.77
[C] 34.97  [D] 44.44

36. The styx number of B₄H₁₀ is

[C] 4012  [D] 4220

37. The redox indicator among the following is:

[C] Fluorescein  [D] Phenolphthalein

38. The percentage of iron in +3 oxidation state in Fe₀.₉O is close to

[A] 22.22  [B] 84.20
[C] 28.59  [D] 18.49

39. A 100 mL buffer solution of pH 7 contains 10 mmol of the acid HA (pKₐ = 7.00), and 10 mmol of the conjugate base A⁻. To this solution, 1.0 mmol of solid NaOH is added. The pH of the resulting solution is

[A] 7.00  [B] 12.00
[C] 7.09  [D] 6.5
40. Among the following, the EPR active species is

[A] Oxy-hemocyanin [B] Cytochrome
[C] Chlorophyll [D] Caboxypeptidase

41. Predict the product in the following reaction:

\[
\text{O} \quad \text{NaBH}_4
\]
\[
\text{THF, 0 }^\circ\text{C} \quad ?
\]

\[
\begin{array}{c}
\text{OH} \quad \text{CO}_2\text{H} \\
\text{OH} \quad \text{CO}_2\text{H} \\
\text{OH} \quad \text{CH}_2\text{OH} \\
\text{OH} \quad \text{CO}_2\text{H}
\end{array}
\]

[A] [B] [C] [D]

42. Second order spectra in \(^1\)H-NMR occur due to

[A] weakly coupled protons [B] strongly coupled protons
[C] high field machines [D] spatially close protons

43. Which of the following is the correct order of increasing molecular ion lifetime?

[A] alcohols < ketones < unbranched hydrocarbons < aromatic compounds
[B] alcohols < unbranched hydrocarbons < aromatic compounds < ketones
[C] ketones < alcohols < unbranched hydrocarbons < aromatic compounds
[D] unbranched hydrocarbons < alcohols < ketones < aromatic compounds

44. The splitting pattern of the hydrogen (marked bold) in the \(^1\)H NMR spectrum of the following compound is:

\[
\begin{array}{c}
\text{H} \\
\text{O}
\end{array}
\]

[A] quint [B] ddt
[C] tdd [D] tt
45. Predict the most probable product in the following transformation.

$$\text{Bu}_3\text{SnH, AIBN} \quad \text{Ph-Me, reflux}$$

![Chemical structures with options A, B, C, D]

46. The major product formed in the following reaction is:

$$\text{CH}_3\text{CH}_2\text{CH}_3$$

![Chemical structures with options A, B, C, D]

47. The product formed in the following reaction is:

$$\text{SOCl}_2 \quad \text{CH}_2\text{CH}_3 \quad \text{Ag}_2\text{O}$$

![Chemical structures with options A, B, C, D]
48. Identify the most appropriate product in the following reaction.

\[
\begin{align*}
\text{Me-} &\text{N}^+\text{HCl} + \text{Me-} &\text{O} = \text{Me} &\text{AcOH} \xrightarrow{\text{Reflux}} ?
\end{align*}
\]

[A] [B] [C] [D]

49. Predict the product in the following reaction.

\[
\begin{align*}
\text{Me-} &\text{C} = \text{C} &\text{O} \xrightarrow{\text{O}_2/\text{O}_2} \text{AcO, DMAP} ?
\end{align*}
\]

[A] [B] [C] [D]
50. Identify the product in the following reaction sequence:

\[
\begin{array}{cccc}
& \text{Succinic anhydride} & \text{Pd/C/H}_2 & \text{TFAA} \\
\text{[I]} & [\text{I}] & [\text{II}] & [\text{III}] \\
\end{array}
\]

\[\text{AlCl}_3\]

[A] [B] [C] [D]

51. Identify the product in the following reaction.

\[
\begin{array}{cccc}
& \text{toluene} & \text{reflux} \\
\text{[I]} & [\text{I}] & [\text{II}] & [\text{III}] \\
\end{array}
\]

\[\text{[A]} \quad \text{[B]} \quad \text{[C]} \quad \text{[D]}\]
52. The "topicity" of the two benzylic protons (H<sub>a</sub>, H<sub>b</sub>) in the compounds I and II is:

![Structures of I and II](image)

[A] Enantiotopic in both I & II  
[B] Diastereotopic in both I & II  
[C] Diastereotopic in I & enantiotopic in II  
[D] Diastereotopic in II & enantiotopic in I

53. Identify the most appropriate reagent for the following transformation:

![Transformation](image)

[A] H<sub>2</sub>, Rh(PPh<sub>3</sub>)<sub>3</sub>Cl  
[B] H<sub>2</sub>, Pd-C  
[C] Li/liq-NH<sub>3</sub>  
[D] LiAlH<sub>4</sub>

54. The major product obtained in the following transformation is:

![Transformation](image)

[A]  
[B]  
[C]  
[D]
55. The suitable reagent system for the following transformation is:

\[ \text{COOH} \quad \text{i. SOCl}_2 \quad \text{ii. CH}_2\text{N}_2 \quad \text{iii. Rh}_2(\text{OAc})_4 \]

[A] i. SOCl\textsubscript{2}; ii. CH\textsubscript{2}N\textsubscript{2}; iii. Rh\textsubscript{2}(OAc)\textsubscript{4}  
[B] i. CH\textsubscript{2}N\textsubscript{2}; ii. SOCl\textsubscript{2}; iii. Rh\textsubscript{2}(OAc)\textsubscript{4}  
[C] i. BF\textsubscript{3}Et\textsubscript{2}O; ii. CH\textsubscript{2}N\textsubscript{2}; iii. Rh\textsubscript{2}(OAc)\textsubscript{4}  
[D] i. CH\textsubscript{2}N\textsubscript{2}; ii. BF\textsubscript{3}Et\textsubscript{2}O; iii. Rh\textsubscript{2}(OAc)\textsubscript{4}

56. A hydrocarbon with the formula C\textsubscript{6}H\textsubscript{14} gives a mixture containing only two monochlorides in photochemical chlorination. One of these compounds solvolyzes very rapidly in ethanol, whereas the other solvolyzes very slowly. The hydrocarbon is:

[A] \[ \text{H}_3\text{C} - \text{CH}_2\text{CH}_3 \]
[B] \[ \text{H}_3\text{C} - \text{CH}_2\text{CH}_3 \]
[C] \[ \text{H}_3\text{C} - \text{CH}_2\text{CH}_3 \]
[D] \[ \text{H}_3\text{C} - \text{CH}_2\text{CH}_3 \]

57. D-Mannose upon reaction with I\textsubscript{2} and acetone at room temperature for 24 h provides:

[A] \[ \text{HO} - \text{O} - \text{O} - \text{OH} \]
[B] \[ \text{HO} - \text{O} - \text{O} - \text{OH} \]
[C] \[ \text{HO} - \text{O} - \text{O} - \text{OH} \]
[D] \[ \text{HO} - \text{O} - \text{O} - \text{OH} \]
58. The product of the following reaction is:

\[ \text{HO} \quad \text{HO} \quad \text{O}_\text{Me} \quad \triangle \quad ? \]

59. The products formed in the following reaction are:

\[ \text{Ph} \]  
1. BH\textsubscript{3}·THF  
2. H\textsubscript{2}O\textsubscript{2}/OH\textsuperscript{−}  
3. PCC  
\[ \rightarrow [I] \]  
[II]  

\[ [A] \quad [B] \quad [C] \quad [D] \]
60. The major product formed in the following reaction is:

\[
\text{hv} \quad \text{Cu}_2\text{Cl}_2 \rightarrow ?
\]

[A]  [B]  
[C]  [D]  

61. 1.0 mol of a diatomic perfect gas at 200 K is compressed reversibly and adiabatically until its temperature reaches 300 K. Its molar heat capacity \( C_{v,m} = 27.5 \text{ J K}^{-1}\text{mol}^{-1} \). The work done \((w)\), internal energy change \((\Delta U)\) and enthalpy change \((\Delta H)\) in kJ, respectively are

[A] -2.75, +2.75, -3.58
[B] +2.75, +2.75, +3.58
[C] +2.75, -2.75, 0.00
[D] +27.5, 0.00, +35.8

62. The equilibrium constant for the gas phase isomerization \( \text{A} \rightleftharpoons \text{B} \) at 500 K is 0.4. A mixture of 10.0 g of A and 20.0 g of B is heated to 500 K in a closed vessel. The mass of A at equilibrium is

[A] 21.4 g
[B] 20.0 g
[C] 18.0 g
[D] 12.3 g
63. For a second order reaction, $A \rightarrow \text{products}$, if the initial concentration of $A$ is $[A]_0$ and the amount reacted at time $t$ is $x$, a linear plot against $t$ is obtained for

\[
\begin{align*}
[A] & \frac{[A]_0 - 2x}{[A]_0 - x} \\
[C] & \frac{x}{[A]_0 - x} \\
[D] & \ln([A]_0 - 2x)
\end{align*}
\]

64. The X-ray diffraction peak for the $(1 1 0)$ plane of a cubic lattice is observed at $2\theta = 22.0^\circ$. The peak for the $(1 2 1)$ plane will appear at a $2\theta$ value of

\[
\begin{align*}
[A] & 38.6^\circ \\
[B] & 24.2^\circ \\
[C] & 19.3^\circ \\
[D] & 12.1^\circ
\end{align*}
\]

65. The standard reduction potentials for $\text{Cu}^{2+}(aq)|\text{Cu}(s)$ and $\text{Cu}^+(aq)|\text{Cu}(s)$ are respectively, $+0.34$ V and $+0.52$ V. The standard Gibbs free energy change for the reaction, $2\text{Cu}^+(aq) \rightarrow \text{Cu}^{2+}(aq) + \text{Cu}(s)$ is

\[
\begin{align*}
[A] & + 15.44 \text{ kJ mol}^{-1} \\
[B] & - 15.44 \text{ kJ mol}^{-1} \\
[C] & + 34.74 \text{ kJ mol}^{-1} \\
[D] & - 34.74 \text{ kJ mol}^{-1}
\end{align*}
\]

66. The pair of observables that can be measured simultaneously with unlimited precision is

\[
\begin{align*}
[A] & p_x, p_y \\
[B] & J_x, J_y \\
[C] & p_z, z \\
[D] & J_z, \phi
\end{align*}
\]

67. The particle with the lowest tunnelling probability through the potential barrier shown below when all of them have $1.2$ eV of kinetic energy is

\[
\begin{align*}
\text{V} & 2.0 \text{ eV} \\
\text{X} & \text{eV}
\end{align*}
\]

\[
\begin{align*}
[A] & \text{electron} \\
[B] & \text{proton} \\
[C] & \text{neutron} \\
[D] & \alpha\text{-particle}
\end{align*}
\]
68. The mean activity coefficient of KCl at 0.01 M concentration is 0.90. The mean activity coefficient at 0.04 M concentration is close to

[A] 38.6  [B] 1.8
[C] 0.81  [D] 0.64

69. The molecule having C₂ symmetry element among the following is

[A] NH₃  [B] CH₄
[C] CH₃Cl  [D] CH₃NH₂

70. The IR active mode of acetylene among the following is (the arrows indicate the direction of atomic displacements)

[C] H − C ≡ C − H  [D] H → C ≡ C ← H

71. Microwave spectrum of H³⁵Cl shows a series of equally spaced lines separated by 6.26 × 10¹¹ Hz. If the reduced mass of H³⁵Cl is 1.63×10⁻²⁷ kg, the bond length of H³⁵Cl would be

[A] 0.91 Å  [B] 1.28 Å
[C] 2.27 Å  [D] 1.61 Å

72. The de Broglie wave length of an electron that has been accelerated through a potential difference of 100 V will be

[A] 0.23 nm  [B] 2.1 nm
[C] 1.3 nm  [D] 0.123 nm
73. The average energy at temperature $T$ of a system having an ensemble of $N$ identical particles (indistinguishable), where each particle can have only two energy levels 0 and $h\nu$ is $[k_B T = \beta]$

[A] $Nh\nu$

[B] $\frac{1}{2} Nh\nu$

[C] $\frac{Nh\nu}{e^{\beta h\nu} + 1}$

[D] $\frac{N}{e^{\beta h\nu} + 1}$

74. The Maxwell’s relation $\left(\frac{\partial F}{\partial V}\right)_T = \left(\frac{\partial S}{\partial V}\right)_T$ results from

[A] $dU = dQ - dW$

[B] $dH = dU + pdV + Vdp$

[C] $dA = dU - TdS - SdT$

[D] $dG = dH - TdS - SdT$

75. $\int \sin^5 x \, dx =$

[A] $\frac{1}{5} \cos^5 x + \frac{2}{3} \cos^3 x - \cos x + c$

[B] $-5 \cos^5 x + 3 \cos^3 x - \cos x + c$

[C] $-5 \cos^5 x + 2 \cos^3 x - \cos x + c$

[D] $\frac{1}{5} \cos^5 x - 2 \cos^3 x + \cos x + c$

76. The net charge of a protein below the isoelectric point, above the isoelectric point and at the isoelectric point are, respectively,

[A] $-1, 0, +1$

[B] $+1, 0, -1$

[C] $-1, +1, 0$

[D] $+1, -1, 0$

77. The number of vibrational normal modes of $\text{CH}_3 - \text{CH}_2 - \text{CH}_3$ is:

[A] 29

[B] 28

[C] 27

[D] 26
78. The vibrational frequency of a first order saddle point is identified with
   [A] a small negative number  [B] a small positive number
   [C] a large positive number  [D] an imaginary number

79. The ionization energy for hydrogen atom is 13.6 eV. The ionization energy for the ground state of Li$^{2+}$ is approximately
   [A] 27.2 eV  [B] 40.8 eV  [C] 54.4 eV  [D] 122.4 eV

80. Which of the following is not a Hermitian operator?
   [A] $x$  [B] $i \frac{d}{dx}$
   [C] $\frac{d^2}{dx^2}$  [D] $i\hbar \frac{d^2}{dx^2}$