(4)

(c) Find the commutator $[\hat{L}^2, \hat{L}_x]$, where $\hat{L}^2$ and $\hat{L}_x$ are the square of the angular momentum operator and x component of the angular momentum operator respectively of a rotating particle.

(d) Write down the Hamiltonian operator for H_2^+ molecule ion. Find root mean square distance of the electron from the nucleus for hydrogen atom in its ground state. Given normalized ground state wave function

$$\Psi_{1s} = \left(\frac{1}{\pi a_0^3}\right)^{\frac{1}{2}} \exp\left(-\frac{r}{a_0}\right), \text{ where } a_0 = \text{Bohr radius.}$$

12. (a) What do you understand by polarizability of a molecule? Why is it usually expressed as polarizability volume?

(OR)

Explain why the polar molecules experience a drop in molar polarization when the frequency of alternating current is increased to $10^{10} - 10^{12}$ Hz.

(b) At STP, the dipole moment of NH_3 is reported to be 1·44 D. Atomic and electric polarizations total about 6 cm^3 mol^{-1}. Calculate the dielectric constant of NH_3. (Assuming NH_3 to be an ideal gas)

(c) Explain the temperature dependence of the susceptibility of a paramagnetic material.   2½+2½+1

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B. Sc. Chemistry Examination, 2024

(5th Semester)

Chemistry (Core)

Paper : Core 14

Time : *Two Hours*   *Full Marks* : 40

(20 marks for each Unit)

Use a separate answer scripts for each Unit.

The figures in the margin indicate full marks.

UNIT—5141 – I

Answer *all* questions.

1. N_2 and CO are isoelectronic molecules but M-N_2 complexes are much weaker compared to M-CO complexes. Offer a reasonable explanation.   2
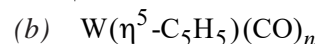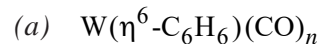
2. Comment on the nature of NO in the following complexes. Which among them is expected to have shorter M-N bond? Give reasons.   2

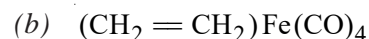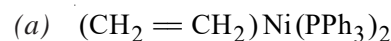   (a) $(\eta^3\text{-allyl})Ru(CO)_2(NO)$

   (b) $(\eta^5\text{-}C_5H_5)Ru(CO)_2(NO)$
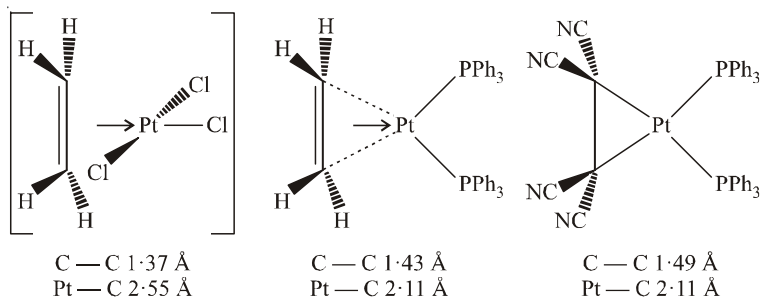
3. Determine the value of n in the following complexes which obey 18-electron rule. 2

(a) $W(\eta^6\text{-}C_6H_6)(CO)_n$

(b) $W(\eta^5\text{-}C_5H_5)(CO)_n$

4. Which of the following metal alkene complexes, do you think, will look most like a metallacyclopropane? Explain your answer. 2

(a) $(CH_2 = CH_2)Ni(PPh_3)_2$

(b) $(CH_2 = CH_2)Fe(CO)_4$

5. Comment on the C — C and Pt — C bond lengths in the following complexes : 2

| C — C 1·37 Å | C — C 1·43 Å | C — C 1·49 Å |
| Pt — C 2·55 Å | Pt — C 2·11 Å | Pt — C 2·11 Å |

6. Acid hydrolysis of $[Co(NH_3)_6]^{3+}$ is highly favourable thermodynamically (Equilibrium constant nearly 10^{25}). But, the reaction does not occur even in moderately strong acidic media. What conclusion can be drawn from such observation? 2

7. Draw energy profile diagrams of A and D mechanism for inorganic substitution mechanism and discuss. 4

8. What are the differences between a crown ether and a cryptand? 2

9. Write a short explanatory note on 'Purple Benzene'. 2

UNIT—5142 – P

10. (a) State and explain Bohr's correspondence principle considering 1-D SHO model.

(b) Evaluate the expectation value of kinetic energy of the harmonic oscillator in the ground state. The ground state normalized wave function of the harmonic oscillator is

$$\Psi_0 = \left(\frac{\alpha}{\pi}\right)^{\frac{1}{4}} \exp\left(-\frac{\alpha x^2}{2}\right),$$ here α is a constant.

2½+2½

11. Answer *any three* questions : 3×3

(a) Find the probability of getting the electron for hydrogen atom in its ground state within Bohr radius (a_0). Given normalized radial part of the ground state wave function is $R_{1s} = \dfrac{2}{a_0^{3/2}} \exp\left(-\dfrac{r}{a_0}\right).$

(b) Consider benzene molecule to be a particle on ring problem. Assuming the radius to be 1·39 Å. Calculate the wavelength of the lowest energy transition in this molecule.