## Department of Chemistry IIT Delhi, CML 100 Minor 2 Examination,
Maximum marks 25 [total time (I+P) 1 hour]
Inorg. Chem. Part (Marks 15)
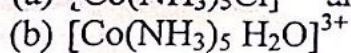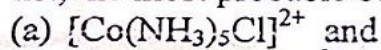
scandium 21 Sc 44.956	titanium 22 Ti 47.867	vanadium 23 V 50.942	chromium 24 Cr 51.996	manganese 25 Mn 54.938	iron 26 Fe 55.845	cobalt 27 Co 58.933	nickel 28 Ni 58.693	copper 29 Cu 63.546	zinc 30 Zn 65.39
yttrium 39 Y 88.906	zirconium 40 Zr 91.224	niobium 41 Nb 92.906	molybdenum 42 Mo 95.94	technetium 43 Tc (98)	ruthenium 44 Ru 101.07	rhodium 45 Rh 102.91	palladium 46 Pd 106.42	silver 47 Ag 107.87	cadmium 48 Cd 112.41
lutetium 71 Lu 174.97	hafnium 72 Hf 178.49	tantalum 73 Ta 180.95	tungsten 74 W 183.84	rhenium 75 Re 186.21	osmium 76 Os 190.23	iridium 77 Ir 192.22	platinum 78 Pt 195.08	gold 79 Au 196.97	mercury 80 Hg 200.59

1. Calculate CFSE based on Δ_0 for the following complexes and determine which two complexes among the following will have the same CFSE based on Δ_0. [2]

   $[MnF_6]^{4-}$, $[Ni(H_2O)_6]^{2+}$, $Cr(H_2O)_6]^{2+}$, $[V(NH_3)_6]^{3+}$, $[Co(NH_3)_6]^{2+}$, $[Cu(H_2O)_6]^{2+}$
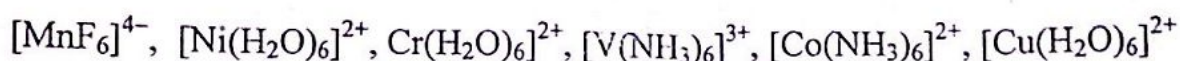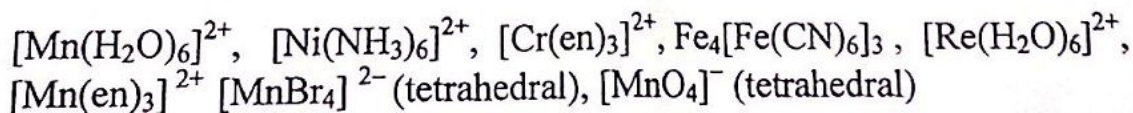
2. Among the given ligands Cl^-, CN^-, H_2O and Py pick out and write those ligands which will form **significantly** distorted octahedral complexes with chromium (II), $[Cr^{2+}]$? Give justification to your answer by crystal field splitting diagram (Py = pyridine). [2]

3. $[Co(H_2O)_6]^{3+}$ is blue in color and $[Co(NH_3)_6]^{3+}$ is orange in color. Pick out from the given list, the most probable observed color of
   (a) $[Co(NH_3)_5Cl]^{2+}$ and
   (b) $[Co(NH_3)_5 H_2O]^{3+}$
   [list: violet, blue, green, yellow, orange, red] [2]

4. From the given set of complexes, pick out and write those complexes whose electronic transitions are **Spin allowed and Laporte forbidden** (*negative marks for wrong answers*) [2]

   $[Mn(H_2O)_6]^{2+}$, $[Ni(NH_3)_6]^{2+}$, $[Cr(en)_3]^{2+}$, $Fe_4[Fe(CN)_6]_3$, $[Re(H_2O)_6]^{2+}$, $[Mn(en)_3]^{2+}$ $[MnBr_4]^{2-}$ (tetrahedral), $[MnO_4]^-$ (tetrahedral)

5. Using the **minimum** number of chlorine ligands make the following bimetallic complexes stable and draw the final structures in the answer book.
   You are **not permitted** to make any more metal–metal bonds or make the complex ionic by adding charges. Also μ_3 bonding is not applicable as it requires minimum 3 metal centres [2]

(A)   (B)
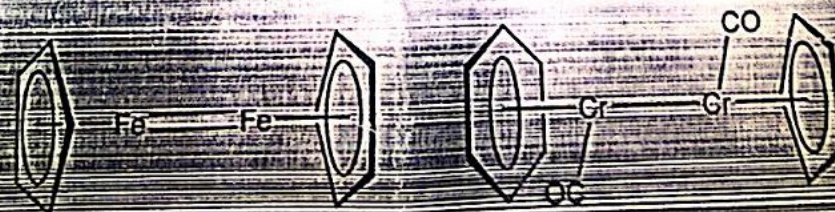
6. Starting from ferrocene show **minimum** number of steps with reagents for making 1,1'dicyanoferrocene [3]

7. Infrared spectral analysis of $V_2(CO)_{12}$ (prepared with great difficulty at very low temperatures) showed three bands at 2014, 2050 and 1830 cm^{-1}. Given that this dimer obeys the 18 electron rule and each vanadium has a coordination number of eight, propose a structure and draw it in your answer book. [2]

Physical Chemistry Part, (Maximum Marks 10)

$h = 6.626 \times 10^{-34}$ Js, 1 amu $= 1.66 \times 10^{-27}$ Kg, $\hbar = 1.06 \times 10^{-34}$ Js

8. (a) Confirm that the wavefunction for the first excited state of a one-dimensional linear harmonic oscillator $\left(Nye^{-y^2/2}\right)$ is a solution of the Schrondinger equation for the oscillator and calculate its energy. N is a constant and $y = x\left(\dfrac{m\omega}{\hbar}\right)^{1/2}$ (2)

(b) What is electrical dipole moment operator ? How does it varies with position? What is the two selection rules in order to have a vibrational transition visible in IR spectroscopy? (2)

9. (a) Calculate if the wavenumber of the J=3 to 2 rotational transition in the pure rotational spectrum of $^{12}C^{16}O$. The equilibrium bond length is 112.81 pm. Calculate the wad(2)ho

(b) Given that the spacing of lines in the microwave spectrum of $^{35}Cl^{19}F$ is constant at 1.033 cm^{-1}, calculate the moment of inertia and bond length of the molecule. (2)

© What kind of surface representation (distribution of particle of a given angular momentum) you expect for a wavefunction (a) constant$^*\sin\theta\cos\varphi$ (b) constant* $\left(3\cos^2\theta - 1\right)$? (Hint: distance of a point on the surface from the origin is proportional to square modulus of the amplitude of the wavefunction at that point). (2)