Unit 6: Tutorial 9: Identification of Cations and Anions.

1. Which of the following anion group give off gas by reacting with dilute acids?

    1. HCO_3^- ,NO_2^- ,$C_2O_4^{-2}$, Br^-

    2. I^-, S^{-2} ,SO_3^{-2} ,CO_3^{-2}

    3. HCO_3^- ,NO_2^- ,S^{2-} ,$S_2O_3^{-2}$

    4. NO_3^- ,NO_2^-,$C_2O_4^{-2}$, CO_3^{-2}

    5. I^-, $S_2O_3^{-2}$, SO_3^{-2} ,HCO_3^-, S^{-2}

2. Which anion group react with dil. H_2SO_4 and release a gas?

    1. HCO_3^-, NO_2^-, S^{-2}, Cl^-

    2. I^-, Br^-, NO_3^-,$C_2O_4^{-2}$

    3. CO_3^{-2},NO_2^- ,S^{-2}, SO_4^{-2},

    4. $S_2O_3^{-2}$,NO_2^-,Br^- ,I^-

    5. NO_3^-, S^{-2} ,HCO_3^- ,$C_2O_4^{-2}$

3. In which of the following situation does a gas not tend to be released?

    1. Add conc. HCl to aqueous $C_2O_4^{-2}$ solution

    2. Add conc. HCl to MnO_2

    3. Add conc. HCl to $KMnO_4$

    4. Add conc. HCl to Na_2SO_3

    5. Add dil. H_2SO_4 to KNO_2

4. When Al powder and NaOH were added to a certain salt, then gas was released forming a colorless solution. When HCl was added to the colorless solution in excess, a white precipitate was formed. What is the salt?

    1.$Pb(NO_3)_2$ 2.$Sn(SO_4)_2$ 3.$Al(NO_3)_3$ 4.$Zn(NO_3)_2$ 5.$CuSO_3$

5. Which reagent can be used to separately identify the aqueous solutions of S^{-2}, SO_3^{-2}, $S_2O_3^{-2}$

    1.$H^+/KMnO_4$ 2.$H^+/K_2Cr_2O_7$ 3. $Br_2(l)$ 4. $Pb(NO_3)_2$ 5. dil. H_2SO_4

6. Which reagent can be used to separate the compounds of $NaNO_2$, Na_2SO_3, $Na_2S_2O_3$, Na_2SO_4.

    1. dil. HCl 2. $Pb(NO_3)_2$ 3. conc. H_2SO_4 4. $H^+/KMnO_4$ 5.NaOH

7. Following observations were reported when tested for the identity of a certain inorganic compound,

    1. Decolorizes acidic $KMnO_4$ solution

    2. A colorless gas is given off when heated with NaOH

    3. When Al powder is added to the product of 2 and upon heating, the colorless gas similar in experiment 2 is released.

    What is the inorganic compound?

    1.NH_4NO_3 2.NH_4NO_2 3. $(NH_4)_2SO_3$ 4. $(NH_4)_2S$ 5.$(NH_4)_2SO_4$

8. When $BaCl_2$ was added to a certain salt, a white precipitate and a colored solution were obtained. A colorless gas was released when HCl was added to the precipitate. When aqueous NH_3 was added to the colored solution, a green precipitate was obtained, then NaOH and H_2O_2 were added to it, a yellow-colored solution was obtained.

    Identify the salt?

    1.$Cr(SO_4)_3$ 2.$Cr_2(SO_3)_3$ 3.$FeSO_3$ 4.$NiSO_3$ 5.$NiSO_4$

9. There are KBr and KI in a certain aqueous solution. Cl_2(aq) was added to this solution and $CHCl_3$ was added to the resulting product.Then the system was shaken rapidly.

    a. Cl_2 oxidizes Br- and I- ions.

    b. the aqueous layer has HIO_3 and HCl.

    c. I_2 is distributed in the aqueous layer and organic layer.

    d. there is a reddish-brown coloration in organic layer.

    Which of the clauses above are true?

    1.a,b 2.b,c 3.a,c,d 4.a,b,c 5.a,b,c,d

10. Which of the following statement is false?

    a. The F^- ion gives a white precipitate with aqueous $AgNO_3$

    b. The F^- ion gives white precipitate with aqueous $Pb(NO_3)_2$

    c. HF does not decolorizes the purple color of acidic $KMnO_4$

    d. The bond strength /energy of F_2 is less than the bond strength /energy of Cl_2

    e. F does not form double bonds.

11. A salt was treated with dilute HCl, a colorless gas was obtained. When this gas was passed into an aqueous hydrogen sulphide, a milky suspension was resulted. Identify the gas.

12. What are the true statements about NO_2^- and NO_3^-,

a.Both ions release gas with dil.H_2SO_4.

b.Both ions respond to the brown ring test with d.H_2SO_4.

c.Both ions tend to release NH_3 gas with Al powder and NaOH.

d.some nitrates don't release NH_3 gas when heated.

13. Which reagent can be used to separate NO_2^- and NO_3^- ions?

a.conc.H_2SO_4 b.conc. HNO_3 c.KI/I_2 d.$H^+/KMnO_4$

14. What happens when NaOH is added to a solution containing "Dewarda alloy"(Zn, Al, Cu) and heated ?

a.NO_3^- oxidizes to NH_3

b.The Zn metal becomes the $[Zn(OH)_4]^{-2}$ ion

c.Al metal becomes the $[Al(OH)_4]^-$ ion

d. NO_2^- oxidizes to NH_3

15. What can happen when an aqueous solution containing NO_2^- and SO_3^{-2} ions is acidified with dil. HCl?

a. NO_2 gas is released c. NO is produced

b. SO_2 gas is released d. H_2SO_4 is formed.

16. What method can be used to separately identify CO_3^{-2} and PO_4^{-3} ions?

a. treat with dil. HCl b. add $BaCl_2$ and HNO_3

c. add $CaCl_2$ d. add ammonium molibdinate and conc. HNO_3

17. In which of the following reactions a gas with an unpleasant odor (rotten egg smell) is released?

a. add HCl to $Na_2S_2O_3$ c. add dil.HCl to FeS

b. add dil.HCl to Sb_2S_3 d. add dil.HCl to ZnS

18. What method can be used to separately identify Br^- and I^-

a. Treat the solutions containing the ions with conc. H_2SO_4

b. Add Br_2 (aq) to the solution containing the ions

c. Add $K_2Cr_2O_7$ and conc. H_2SO_4 to the solution

d. Add Cl_2(aq) and CCl_4 to solution and shake.

19. A salt on reactions with dilute HCl gives colored solution and a gas with characteristic odor. The gas give black colored precipitate with lead nitrate. Identify the anion in the salt.

20. 1. **Statement:** It is possible to use $K_2Cr_2O_7$ and con.H_2SO_4 to separate Cl^- and Br^-
    2. **Explanation:** Cl^- forms CrO_2Cl_2 because of $K_2Cr_2O_7$ and con. H_2SO_4

    Identify whether the 1 and 2 above are true or false and whether 2 explains the 1st.

21. 1. **Statement:** One cannot use $Na_2S_2O_3$ to separate $Pb(NO_3)_2$ and $AgNO_3$ solutions

    2. **Explanation:** both PbS_2O_3 and $Ag_2S_2O_3$ are white.

22. Element **X** has both XO_2^- and XO_3^- anions. Element **Y** has YO_4^{-3} anion.

    Write the observations when these anions are treated with the specified reagent.

Reagent	XO_2^-	XO_3^-	YO_4^-
1. dil.HCl			
2. Al powder+NaOH and heat			
3. $BaCl_2$			
4. $H^+/KMnO_4$			

23. Consider the following ions in separate solutions

    NO_2^-, CO_3^{-2}, CrO_4^{-2}, S^{-2}

    Write an experimental process to separately identify these ions.

24. Write experimental method to separately identify SO_3^{-2} and SO_4^{-2} ions in a aqueous solution .
25. Consider the following ions in a aqueous solution.

    Cl^- , Br^- , I^-

    1. Write an experimental process to identify/separate these ions.
    2. How would you attempt to determine the concentration of I^-? Identify a gravimetric method and a titrimetric method.

26. An aqueous solution with a chloroform layer, on treating with chlorine water gives a colored choloroform layer. Adding $AgNO_3$ to this aqueous solution gave a yellowish precipitate which is soluble in conc. NH_3 but not in dil. NH_3. Write the anion contained in the salt explain the reactions by means of balanced equations.

27. A salt on heating with dil.H_2SO_4 give off a gas.The gas decolorizes both coloured rose petals and bromine water. This gas reacts with H_2S to form a milky suspension. Write the anion contained in the salt and identify the gas. Explain reactions by means of balanced equations.

28. An aqueous solution of salt on treating with $AgNO_3$ gives a white precipitate. When the precipitate was heated, it turns black colour. Identify the anion in the salt.

29. A salt when treated with dil. H_2SO_4 given a colorless gas. The gas on passing through lime water produced milky precipitate. The precipitate dissolved on further passing of the gas. Write the anion contained in the salt and also the gas.

30. An aqueous solution of a particular salt when treated with $BaCl_2$ gives a white precipitate. It is insoluble in dil.HCl. Identify the anion contained in the salt.

31. When an aqueous solution of a salt was treated with hydrogen peroxide, a reddish brown solution forms.The solution given when treated with chloroform, the choloroform layer turns purple. Identify the anion present in the salt.

32. (Past papers)

(*a*) **X**, **Y** and **Z** are coordination compounds. They have an octahedral geometry. The atomic composition of the species in the coordination sphere (i.e. metal ion and the ligands coordinated to it) in **X**, **Y** and **Z** are $FeH_{10}CNO_5S$, $FeH_8C_2N_2O_4S_2$ and $FeH_6C_3N_3O_3S_3$ respectively. The oxidation state of the metal ion in all three compounds is the same. In each compound, **two types** of ligands are coordinated to the metal ion. If these compounds contain **non-coordinated** anions, they are of the same type.

An aqueous solution **S** contains **X**, **Y** and **Z** in the molar ratio 1:1:1. The concentration of **each** compound in solution **S** is 0.10 mol dm^{-3}. When excess $AgNO_3$ solution was added to 100.0 cm^3 of **S**, a yellow precipitate was formed. The precipitate was washed with water and oven dried to a constant mass. The mass of the precipitate was 7.05 g. This precipitate does not dissolve in conc. NH_4OH.

(Relative molecular mass of the chemical compound in the yellow precipitate = 235)

(i) Identify the ligands coordinated to the metal ions in **X**, **Y** and **Z**.

(ii) Write the chemical formula of the yellow precipitate.

(iii) Giving reasons, determine the structures of **X**, **Y** and **Z**.

(iv) Given below is the structure of ethylenediamine (en)

$$H_2\ddot{N}-CH_2-CH_2-\ddot{N}H_2$$

Ethylenediamine coordinates to the metal ion M^{3+} through the two nitrogen atoms, to form the complex ion **Q** (i.e. metal ion and ligands coordinated to it). **Q** has an octahedral geometry.

Write the structural formula of **Q** and draw its structure.

Note: Consider that only ethylenediamine is coordinated to the metal ion. Use the abbreviation 'en' to denote ethylenediamine in your structural formula.

33.

(*a*) **X** and **Y** are *s*-block elements of the Periodic Table. They react with water to form hydroxides. The hydroxide of **X** is more basic than that of **Y**. The hydroxide of **X** is used in the manufacture of baby soap. The hydroxide of **Y** is commonly used to identify the gas **Z** that is one of the main gases responsible for global warming.

(i) Identify **X** and **Y**.

X ☐ **Y** ☐

(ii) Write the electronic configurations of **X** and **Y**.

X = ...

Y = ...

(iii) Write the colour of the flame given by salts of **X** and **Y** in the flame test.

X = ... **Y** = ...

(iv) Indicate the relative magnitudes of the following in respect of **X** and **Y**.

I. Atomic size ☐ > ☐

II. Density ☐ > ☐

III. Melting point ☐ > ☐

IV. First ionization energy ☐ > ☐

(v) Identify **Z**.

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(vi) Using balanced chemical equations **only**, indicate how the hydroxide of **Y** could be used to identify **Z**.

Note: Indicate precipitates, if any, using "↓" and colours of precipitates/solutions used in the identification.

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(vii) A natural source of **Y** in which it is present as a carbonate is used as a raw material in the manufacture of a disinfectant.

I. Name the natural source. .....

II. Identify the disinfectant. .....

III. Write the steps in the manufacturing process of the disinfectant, using balanced chemical equations **only**.

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(5.0 *marks*)

(*b*) (i) Complete the reactions given below by selecting the appropriate solution from the given list and writing in the box.

List of solutions (not in order)

$Na_2S_2O_3(aq)$, $AgNO_3(aq)$, $K_2SO_4(aq)$, $(NH_4)_2CO_3(aq)$, $BaCl_2(aq)$, $KI(aq)$

Note: A solution should be used **only once**.

I. $BaCl_2(aq)$ + ☐ ⟶ **A** (White precipitate that dissolves in dil. HCl to give a clear solution)

II. $Pb(NO_3)_2(aq)$ + ☐ ⟶ **B** (Yellow precipitate that dissolves in hot water)

III. $AgNO_3(aq)$ + ☐ ⟶ **C** (White precipitate that turns black on standing)

IV. $K_2SO_3(aq)$ + ☐ ⟶ **D** (White precipitate that dissolves in dil. HCl)

V. $NaBr(aq)$ + ☐ ⟶ **E** (Pale yellow precipitate that dissolves completely in conc. ammonia)

VI. $Ba(NO_3)_2(aq)$ + ☐ ⟶ **F** (White precipitate that does **not** dissolve in dil. HCl)

(ii) Write the chemical formulae of the precipitates **A** to **F**.

A ..... **B** .....

C ..... **D** .....

E ..... **F** .....

(iii) Write balanced chemical equations for the dissolution of precipitates **A**, **D** and **E** in (b)(i) above.

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34.

.(*a*) **X** is an *s*-block element in the Periodic Table. The first, second and third ionization energies of **X**, in kJ mol^{-1} are 738, 1451 and 7733 respectively. **X** reacts slowly with hot water, liberating $H_2(g)$ and forming its hydroxide. The hydroxide is basic. **X** also liberates $H_2(g)$ on reaction with dilute acids. **X** burns in air with a bright white light. The cation of **X** contributes to hardness of water.

(i) Identify **X**. **X**: .....

(ii) Write the ground state electronic configuration of **X**. .....

(iii) Write the chemical formulae of the **two** compounds formed when **X** burns in air.

..... and .....

(iv) Consider the given compounds of the elements in the group in the Periodic Table to which **X** belongs. In the given boxes, write whether the indicated property **increases** or **decreases** down the group.

I. Solubility of sulphates in water ☐

II. Solubility of hydroxides in water ☐

III. Thermal stability of metal carbonates ☐

Give reasons for your answer in III.

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(v) Identify the element in the *s*-block of the Periodic Table, which reacts in a similar manner to **X** with $H_2(g)$, $O_2(g)$ and $N_2(g)$, but does **not** belong to the same group as **X**.

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(vi) Identify another **metal ion** that contributes to hardness of water.

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(vii) Identify the compound most commonly used to remove hardness of water.

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(viii) **X** is a component of a well-known reagent used in organic chemistry. Give the **name** of this reagent.

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(50 *marks*)

(*b*) Test tubes labelled **A** to **E** contain aqueous solutions of $Na_2S_2O_3$, Na_2CO_3, KNO_2, KBr and Na_2S (not in order). The characteristics of the solutions obtained and gases evolved on addition of dil. HCl (warming if required) to each of the test-tubes **A** to **E** are given in the table below.

Test-tube	Appearance of solution	Gas
A	colourless	colourless and odourless
B	colourless	reddish-brown with a pungent odour
C	colourless	colourless with a rotten egg odour
D	turbid	colourless with a pungent odour
E	colourless	not evolved

(i) Identify the solutions in each of the test-tubes **A** to **E**.

A : ..... **C** : ..... **E** : .....

B : ..... **D** : .....

(ii) Write balanced chemical equations for the reactions that take place in test-tubes **A**, **B**, **C** and **D**.

In **A** : .....

In **B** : .....

In **C** : .....

In **D** : .....

(iii) Write a chemical test to identify each of the gases evolved in **A**, **C** and **D**.
Note: Observations are also required.

In **A** : .....

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In **C** : .....

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In **D** : .....

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(50 *marks*)

Unit 6 - Tutorial 8- Chemistry of *d*-block elements

1. What are the two elements with the highest and the lowest stable oxidation state of the elements, belonging to the first row of d block, respectively?

   1.Cr, Ti 2.Cr,Cu 3.Mn, Cu 4.Mn,V 5. Cr,Sc

2. What are the 2 elements give the highest and the lowest first ionization energy, belonging to the first row of d block, respectively ?

   1.Ti, Cr 2.Sc ,Ni 3.Cu, Sc 4.Zn ,Sc 5.Mn ,V

3. Which of the following pair of 3d elements give maximum and minimum atomic radius,

   1.V, Zn 2.Sc, Ni 3.Cu, Sc 4.Ti, Cr 5.Mn, Ni

4. Among the 3d elements, which pair of elements can be expected to have the highest and the lowest electronegativity?

   1.V, Zn 2.Sc ,Ni 3.Cu, V 4.Cu ,Sc 5.Mn, Sc

5. Which of the following pair of 3d elements gives the minimum and maximum value of density?

   1.Cu ,Sc 2.V ,Zn 3.Mn ,Sc 4. Sc ,Ti 5. Sc ,Cu

6. Among the 3d elements ,which pair of elements have the lowest and highest MP s?

   1.V, Cu 2.Sc ,Cu 3.V, Sc 4.Zn ,V 5.V, Zn

7. Which of the following elements have the highest electro conductivity?

   1.V 2.Sc 3.Fe 4.Cu 5.Co

8. Which of the following ions does not exist among the complex ions form by transitional elements ?

   1.$[CuCl_4]^{-2}$ 2.$[Sc(OH_2)_2]^{+}$ 3.$[Cr(NH_3)_6]^{+3}$ 4.$[Co(NH_3)_6]^{+3}$ 5.$[CoCl_4]^{-2}$

9. Metal X was dissolved in Con.HNO_3 to form an aqueous solution. A yellowish brown solution was obtained. After adding HCl into to this aqueous solution, H_2S was bubbled. A black precipitate was formed. What is x?

   1.Cu 2.Ni 3.Co 4.Fe 5.Mn

10. What is /are correct about MnO_4^- ion?

    a) The ion can become Mn^{+2} in the acidic medium
    b) The ion can be as MnO_2 in the acidic medium
    c) The ion can become as MnO_4^{-2} by heating
    d) Mn^{+2} ion can become coloured as acid is added.

11. Melting point of Mn is lower than the melting point of Cr because It's difficult for electrons to get displaced to the electron sea. Explain this statement.
12. In aqueous solution, Cr^{+3} ion is more stable than Cr^{+2} ion; Cr^{+2} ion can oxidizes to Cr^{+3} easily.

    State whether the statements are true of false and give your reasons.

13. What is /are the true statements about 3d transitional elements .

    a. The lowest BP is belongs to Mn and the highest BP is to V
    b. All oxides formed at the maximum oxidation state are coloured.
    c. The oxidizing number is higher, compared to the elements in s block.
    d. Aqueous solution of all these salts are coloured .

14. What is /are true about $[Co(NH_3)_4(NO)Cl]SO_4$,

    a. Coordination number of Co is 6
    b.it is colourless in aqueous solution
    c. oxidation number of Co is +2
    d.$BaCl_2$ solution white precipitate with aqueous solution

15. Statement 1: Aqueous solutions of Cu^{+2}, Zn^{+2} and Fe^{+2} give clear transparent solutions with excess aqueous NH_3.

    Statement 2: 3d cations with empty valence orbitals gain unpaired electrons from NH_3 to form complexes.

16. The coloured compound is,

    1.$[Zn(NH_3)_2(H_2O)_4]$ 2.$[Cu(NH_3)_2(H_2O)_4]Cl$ 3.$[Sc(NH_3)_3(H_2O)_3]_2(SO_4)_3$ 4.$Ti(NO_2)_4$ 5.$[Mn(OH)_2(H_2O)_4]Cl$

17. There are two green coloured sodium salts containing two elements belonging to *d* block, in a certain aqueous solution. When H_2O_2 solution was added in the basic medium to it, a reddish brown precipitate and a yellow solution were obtained. What are the elements present in salts.

    1.Fe and Mn 2.Mn and Ni 3.Fe and Ni 4.Cr and Ni 5.Mn and Cr

18. An excess of NaOH was added to an aqueous solution containing certain metal cation. when H_2O_2 is added to the resulting product. Which solution/s gives a noticeable colour change ?

    a.Cr^{+3} b.Ni^{+2} c. Ag^{+} d.Fe^{+2}

19. 1.gives a blue colour solution with excess of NH_4OH
    2.does not precipitate with H_2S in dil.HCl
    3.Which gives yellow-brown solution with con.HCl

    1.Cr^{+3} 2.Ni^{+2} 3.Co^{+2} 4.Cu^{+2} 5.Mn^{+2}

20. A,B and C are three cation which precipitate with NH_4OH .This precipitates are dissolves in excess NH_4OH. A ,B and C are?

    1.Cu^{+2} Ni^{+2} Cr^{+3} 2.Cu^{+2} Ni^{+2} Al^{+3} 3.Zn^{+2} Cu^{+2} Ni^{+2} 4.Zn^{+2} Cu^{+2} Cr^{+3} 5. Ag^{+} Zn^{+2} Al^{+3}

21. 1. Gives a yellow - brown solution with conc. HCl.
    2. When shaken with KI/I_2 and CCl_4 solution, turns the CCl_4 layer to purple.
    3. Doesn't give a precipitate when H_2S is treated to an acidic solution.
    The cation is?

    1.Cr^{+3} 2.Ni^{+2} 3.Cu^{+} 4.Fe^{+3} 5.Mn^{+2}

22. The following observations were given with a soluble salt of metal **M**,
    1. A blue solution was obtained when the salt was dissolved in water.
    2. A dark blue solution was obtained when excess ammonia was added to an aqueous solution of the salt.
    3. A yellow solution was obtained when the salt was dissolved in excess conc. HCl
    4. A black precipitate is given when the above solution of 2, was dilute from water and treated with H_2S,
    Identify the **M**.
    Write chemical equations for each of the above observations.

23. The carbonate of element **X** from d block reacts with dil.HCl to form a pink solution.This solution turns blue when con. HCl is added.

    i. Identify **x**.
    ii. Write the electronic configuration of **x**
    iii. Introduce the species that is responsible for the pink and blue colours and name their shapes.
    iv. What are types of bonds in the pink species.
    v. Why does the blue species not form when Y is treated with dil.HCl.
    vi. Write the observation when blue solution was diluted from water.
    vii. Give one medical use and one industrial use each for x or its compounds.

24. **M** is a first order element in the d block. That shows its highest stable oxidation state, MO_4^- and this anion gives another oxo anion when a base is added to the solution.

    i. identify **M**.
    ii. Write the complete electronic configuration of **M**.
    iii. Write the colour of MO_4^-
    iv. Write the formula and colour of the other oxo anion of M
    v. Write the balanced chemical equation for the above reaction.
    vi. What can be observed when an acidic is added to the other oxo anion of M. Write the balanced chemical equation.
    vii. Write the stable lowest oxidation number of M in aqueous solution.

25. M is a first row (3d) transitional element. There are six of unpaired electrons for this element.

    i. Identify M
    ii. Write the complete electronic configuration of M
    iii. Write the observations when an aqueous solution containing M^{+3} is heated with NaOH and H_2O_2.
    iv. Write the formulas and colours of two other compounds of M in which M is present in the same oxidation state as the product obtained in 3. above.
    v. What can be observed when an acid is added to the resulting solution after the reaction. Write the balanced chemical equations.
    vi. What can be observed when base is added to the solution obtained in (5) above ? Write the balanced chemical equations .

26. A 3d transitional element **M** reacts with dil.H_2SO_4 to form a light green solution. When NH_4OH is added, this solution gives a light green yellowish brown.

    i. Identify **M**
    Write the complete electronic configuration of **M**
    ii. Identify the species responsible/ cause for the light green and yellowish brown precipitate mentioned above.
    iii. Write the balanced chemical equations relating to the colour change of the above precipitate.
    iv. What is the most common (positive) oxidation state of **M.**
    v. Give three chemical tests that can be carried out using only NH_4SCN, NH_4OH, KI to distinguish between the oxidation states in (5) above.
    vi. Write two tests which give precipitates of the same colour to differentiate between the oxidation states in 5 above.
    vii. Give one instance where **M** is used as a catalyst in chemical industry.

27. A green coloured precipitate (**A**) was added to a portion of an aqueous solution. When conc.HCl was added to it, the precipitate dissolved to give a yellow coloured solution(**B**). This solution was diluted with water and H_2S

passed. No precipitate was given. The remainder of the starting solution was made basic with NH_4Cl/NH_4OH. When H_2S was passed through this solution, a precipitate was given.Identify the (**C**) cation in the solution. Write the chemical species corresponding to **A**, **B**, **C**.

28. M is a 3d transitional element. **M** forms stable MO_2 oxide which is white in colour.
    1. Identify **M**
    2. Write the complete electronic configuration of M
    3. Write one industrial use for M and MO_2.

29. When a green colour salt is dissolved in water, the solution turns blueish purple colour. When dil.HCl is added to the solution, it forms unipositive complex ion and turns green. Identify the cation in the salt.

30. **L** and **M** are 3d transitional elements. L forms oxyanion which have tetrahedral shape. **M** forms $\mathbf{M^{+2}}$ cation. One mole of oxyanion of L reacts with five moles of $\mathbf{M^{+2}}$ and oxidize it to $\mathbf{M^{+3}}$ and forms $\mathbf{L^{+2}}$. $\mathbf{M^{+3}}$ is a yellowish-brown coloured aqueous solution and it can liberate I_2 from KI.

    i. Write the oxidation state of **L** in oxyanion.
    ii. What are the elements of **L** and **M**?
    iii. Write the chemical formula of the oxyanion of **L**.

31. **M** produces a cation which forms a blue colour solution with conc. HCl .

    1 .Write the chemical symbol of **M**.

    2. Write the complete electronic configuration of **M**.

    3. Which oxidation state is most likely to exist considering the electron configuration to **M**.

    4. How would an aqueous solution containing cation in stable lowest oxidation state of **M** react with aqueous NaOH.

    5. Under certain conditions, the reactions between aqueous NH_3 and an aqueous solution containing the cation of the lowest oxidation state of **M** appear to be different from the reaction in (4) above. How do you explain it?

    6. Write the formula of chemical species responsible for the blue colour of **M**.

    7. Write the observations and the reason when excess water was added to the chemical species of blue colour **M**.

32. **A** is a coloured inorganic salt containing metallic element of **M**.

When **A** is heated to give a green residue called **B** =(M_2O_3),a colourless gas **C** and water vapor. 1 mol of **A** gives 1 mol of **B** residue. **C** gas reacts with heated Mg to form a white solid **D**.

D reacts with water to give a gas **E** which turns red litumas to blue. When **A** was heated with Na_2CO_3 **E** gas was formed. When green colour **B** was heated with basic H_2O_2 solution, it resulted in a solution of yellow coloured which is known as **F**.

1.Name **A**, **B**, **C**, **D**, **E** and **F**.
2.Write balanced chemical equations for each reactions.

33. An orange crystaline substance **A** was heated to give a green residue **B** and a colourless and odorless gas **C**. When a piece of Mg was burned with **C** gas to give white precipitate called **D**. Then water was added to **D,** a gas was released which turned brown on a filter paper moistened with Nessler's reagent. Residue **B** was heated with base and $KClO_3$ to give a yellow solution **F**, which on acidification turned orange to give **G**.

    1. Identify **A**, **B**, **C**, **D**, **E**, **F** and **G.**

    2.Write the balanced chemical equations .

34. A white substance reacted with dil. H_2SO_4 to give colourless **B** gas and colourless solution. When **B** was treated with $K_2Cr_2O_7$ gives a precipitate and turns into a green colour **D** solution. A substance **E** when burned in air gave a gas **F** and this gas reacted with **B** to give **E** and a colourless liquid. This colourless liquid turned blue when mixed with anhydrous $CuSO_4$, and the resulting solution gave a precipitate when mixed with NH_3. This precipitate dissolved in excess NH_3 to give **G**.

    1. Identify **A**, **B**, **C**, **D**, **E**, **F** and **G**.
    2. Write the all balanced chemical equations .

35. If one drop of conc. NH_3 is added to a solution of Chromium (III) sulphate given a green coloured precipitate **A** is produced. **A** was dissolved in excess liquid ammonia and given a yellow coloured solution. **A** was dissolved in aqueous NaOH and given a green colour solution called **C**. When H_2O_2 was added to **C** , given a yellow colour solution called **D**. When dilute H_2SO_4 was added to **D**, given **E** and turned to orange .

    Identify **A**, **B**, **C**, **D**, **E**, **F** and **G**.

36. **L** and **M** are 3d trasitional elements. **L** is a tetrahedral oxyanion. **M** forms M^{+2} cation and one mole of **L** (oxyanion) is reacted with 5 mol of $\mathbf{M^{+2}}$ and oxide to $\mathbf{M^{+3}}$ and forms $\mathbf{L^{+2}}$. $\mathbf{M^{+3}}$ is a yellowish-brown coloured aqueous solution and it release I_2 from KI.

    1. Write the oxidation state of oxyanion of **L**.

    2.What the elements of **L** and **M**.

    3.Write the formula of the oxyanion of (**L**)

    4.Give the oxidant and the name of process used industrially to convert M_2O_3 to M.

    5.Give a reaction useful $L(OH)_2$ in quantitative analysis.

QUESTIONS FROM PAST PAPERS

Question 37 – (2001)

M is a first-row d block element. It shows the highest stable oxidation state in MO_4^-

1) Write the **complete** electronic configuration of **M**.
2) Identify **M**.
3) Write the **stable lowest** oxidation state of **M** in an aqueous solution.
4) Write the reagents required to convert MO_4^- to a species with the oxidation state given by you in (3).
5) Write one important use of **M**.

Question 38 – (2002)

M is a first row (3d) transition element. The atoms of this element have six unpaired electrons each.

1) Identify **M**.
2) Write the complete electronic configuration of **M**.
3) Write the balanced chemical equation for the reaction that occurs when an aqueous solution containing $\mathbf{M^{3+}}$ is warmed with NaOH and H_2O_2. (the accepted chemical symbol should be used for M)
4) What is the colour of the solution obtained after carrying out the reaction mentioned in (3)?
5) Give two other compounds of **M** where **M** is in the same oxidation state as in the product obtained in (3)?
6) Give one important industrial use of **M**.

Question 39 – (2002)

Labels of bottles containing aqueous solutions of KI, H_2O_2, $FeCl_3$ and $K_3[Fe(CN)_6]$ have fallen off. In an attempt to identify them, these bottles were labeled as **A, B, C** and **D**. the solutions were mixed in pairs in separate test tubes as indicated below. Each of the mixtures so obtained was then acidified and shaken with $CHCl_3$. The colours of the $CHCl_3$ layers are given below.

Experiment	1	2	3	4
Solutions mixed	A + C	B + C	C + D	B +D
Colour of the $CHCl_3$ layer	Colourless	Colourless	Purple	Purple

Addition of **A** to the mixture obtained in experiment (4) above, produced a deep blue precipitate in the aqueous layer.
Identify **A, B, C** and **D**, giving reasons.

Question 40 – (2003)

X is an element with atomic number less than 40. Some properties relevant to **X** are given below.

Maximum oxidation state	+5
Electrical conductivity	Comparable to that of Al
Highest oxide	Weakly acidic
Density	6.1 g cm^{-3}

1) To which block of elements does **X** belong?
2) Write down the chemical symbol of **X**.
3) Write down the complete electronic configuration of X.
4) Write down the chemical formula of the highest oxide of **X**.
5) Write down one industrial use of the highest oxide of **X**.
6) What are the other oxidation states, if any, shown by **X**?

Question 41 – (2004)

When the carbonate of a d block element **X** reacts with dil. HCl, a pink solution is formed. This solution turns blue upon the addition of conc. HCl.

1) Identify **X**.
2) Write down the complete electronic configuration of **X**.
3) Identify the species responsible for the pink and blue colours and name their shapes.
4) What types of bonds are found in the pink species?
5) Why is the blue coloured species **not formed** when **X** is treated with dil. HCl?
6) What can be observed when the blue solution is diluted with water?
7) Give one medical use and one industrial use of **X** or its compounds.

Question 42 – (2005)

M is a 3d- transition element. **M** forms a stable dioxide $\mathbf{M}O_2$, which is white in colour.

1) Identify **M**.
2) Write the complete electronic configuration of **M**.
3) Give one industrial application in each case for **M** and $\mathbf{M}O_2$.

Question 43 – (2005)

The tests performed on a solution prepared by dissolving two 3d-transtion metal chlorides in water (solution **S**) and the relevant observations are given below.

	TEST	OBSERVATION
A	Aqueous NaOH was added to solution **S**.	A blue-green precipitate was observed
B	Solution **S** was warmed with aqueous NaOH and H_2O_2 and filtered.	A precipitate and a yellow filtrate were obtained
C	Conc. HCl was added to the precipitate obtained in (**B**)	A yellow solution was obtained
D	Diluted the yellow solution obtained in (**C**) and passed H_2S.	A black precipitate was obtained

1) Identify the cations present in **S**.
2) Identify the respective ion responsible for the yellow colour of the filtrate form test (**B**) and the yellow colour of the solution obtained in test (**C**). Write balanced chemical equations for the formation of these two ions in the above reactions.
3) What do you expect to observe when the filtrate from (**B**) is acidified? Give the relevant balanced chemical equation.

Question 44 – (2006)

L and **M** are 3d transition elements.
L forms an oxyanion which is tetrahedral in shape.
M forms a cation $\mathbf{M^{2+}}$.
One mole of the oxyanion of **L** reacts with five moles of $\mathbf{M^{2+}}$, oxidizing it to $\mathbf{M^{3+}}$ and forming $\mathbf{L^{2+}}$.
An aqueous solution of $\mathbf{M^{3+}}$ is yellow-brown colour and liberates I_2 from KI.

1) Deduce the oxidation state of **L** in the oxyanion.
2) What are the elements **L** and **M**?
3) Write the chemical formula of the oxyanion of **L**.
4) Give the reducing agents and the reaction conditions employed in a method used industrially to convert $\mathbf{M}_2O_3$ to the element **M**.
5) Give one reaction of $\mathbf{L}(OH)_2$ useful in quantitative analysis.

Question 45 – (2008)

The 3d transition element **M** reacts with dil. H_2SO_4 forming a pale green solution. On addition of NH_4OH this solution gives a light green precipitate. This precipitate turns yellow brown with time when kept exposed to air.

1) Identify **M**.
2) What are the most common (positive) oxidation states of **M**?
3) Give **one** test to distinguish between the concentrations of **M** in each of the oxidation states given in (2) when present together in a sample.
4) Outline a method to determine quantitatively the concentrations of **M** in each of the oxidation states given in (2) when present together in a sample.
5) Identify the species responsible for the light green and the yellow-brown precipitates mentioned above.
6) Give one instance where **M** is used as a catalyst in chemical industry.
7) Give the chemical formulae and the names of **two** ores used for the extraction of **M**.

Question 46 – (2010)

The 3d block element **M** forms a compound **A**, which has the formula $2\mathbf{MX}O_3.\mathbf{M}(OH)_2$.
Here, the element **X** belongs to the p block. The compound **A** reacts with conc. HCl to give a colourless, odourless gas **B** and a yellow-coloured solution **C**. When **A** reacts with dil HCl, it gives the same (colourless, odourless) gas **B** and a green coloured solution **D** containing two complex ions of **M**. When solution **D** is diluted with water, a light blue coloured solution **E** is formed. When a small amount of NH_4OH is added to **E**, a blue coloured gelatinous precipitate **F** is formed. **F** dissolves in excess NH_4OH to give a dark blue coloured solution **G**. When solution **E** is treated with excess KI, the precipitate **M**I and iodine are formed as the only products.

1) Identify the elements **M** and **X**.
2) Give the electronic configuration of **M**.
3) Give the common oxidation numbers of **M.**
4) Write the formulae of the ionic species responsible for the colours of the following solutions and give their IUPAC names.
   I. Solution **C**
   II. Solution **D**
   III. Solution **E**
   IV. Solution **G**
5) Identify the gas **B** and the precipitate **F**.
6) Give the balanced chemical equation for the reaction of solution **E** with excess KI.
7) Using the reaction of **E** with KI, state the steps involved in the experimental determination of the mass percentage of **M** in a sample of **A** provided.
   Indicate how you would calculate the mass percentage of **M** from your experimental data.
8) Write separate balanced chemical equations for the reactions of **M** and **X** with hot conc. H_2SO_4.
9) When common salts of **M** are heated with certain easily oxidizable compounds under **basic** conditions, $\mathbf{M}_2O$ is precipitated. Write a balanced **half reaction** for this process and give one important use of this reaction.
10) Give **two** important commercial uses of **M**.

Question 47 – (2012)

The following questions are based on the transition metal, Mn and its compounds.

1) Give the electronic configuration of Mn.
2) State the common oxidation states of Mn.
3) Give the chemical formulae of the oxides formed by Mn oxidation states.
   Indicate whether each of these oxides is acidic, amphoteric or basic.
4) Give the IUPAC name of $KMnO_4$.
5) Mn has the lowest melting point and the lowest boiling point among the 3d transition elements. Explain why this is so.
6) What would you expect to observe when a dilute ammonia solution is added to an aqueous solution of Mn^{2+} and then left exposed to the air?
7) An aqueous solution of $KMnO_4$ turns green upon addition of conc. KOH. On diluting the green solution with water or acid, a purple solution and a blackish brown precipitate are obtained.
   Write balanced chemical equations to explain these observations.
8) Give one important use of each of the following.
   a) $KMnO_4$ (other than as an oxidizing agent)
   b) Mn metal
9) Give half reactions to show how $KMnO_4$ behaves as an oxidizing agent in acidic and basic media.
10) Indicate two problems you may expect when using $KMnO_4$ as an oxidizing agent.

Question 48 – (2012)

a) A 3d block element **M** forms an ion $\mathbf{M}^{n+}$. This ion can be oxidized by MnO_4^- in a dil H_2SO_4 medium to give the $\mathbf{M}O_2^+$ ion. In an experiment, 30.0 cm^3 of 0.100 mol dm^{-3} $KMnO_4$ was required to oxidize 5.00 $\times 10^{-3}$ mol of $\mathbf{M}^{n+}$ to MO_2^+. Use this data to calculate the value of *n*.

b) The following procedures I and II were used to determine the percentage of Cu in the Cu containing alloy **Z**.
Procedures:

I. A sample of 2.80 g of the alloy **Z** was dissolved in 500.0 cm^3 of dil. H_2SO_4. Addition of excess KI to 25.0 cm^3 of this solution produced the white precipitate CuI, and I_2 as the only products. The liberated I_2 was titrated with $Na_2S_2O_3$ solution using starch as the indicator. The volume of $Na_2S_2O_3$ solution required was 30.0 cm^3.

II. To 25.0 cm^3 of $K_2Cr_2O_7$ solution prepared by dissolving 1.18 g in 500.0 cm^3 of distilled water, 20 cm^3 of dil. H_2SO_4 and excess KI were added. The liberated I_2 was titrated with the $Na_2S_2O_3$ solution used in procedure I with starch as the indicator. The volume of $Na_2S_2O_3$ required was 24.0 cm^3.

1) Give balanced chemical equations for the reactions taking place in procedures I and II.
2) Determine the percentage of Cu in alloy **Z**.
3) Indicate the colour changes you would observe at the end points of the titrations in procedures I and II.
(O = 16, K = 39, Cr = 52, Cu = 63.5)

Question 49 – (2013)

The following questions are based on the transition metals, V and Cr and their compounds.

1) Give the ground state electronic configuration of V.

2) State the positive oxidation states of V.

3) Give the chemical formulae of the oxides formed by V in the positive oxidation states given in (2) above. Indicate whether each of these oxides is acidic, amphoteric or basic.

4) Write the chemical formulae of **two** oxo cations formed by V. State their colours in aqueous acidic medium.

5) What is the simplest ion that chromium forms in aqueous solution? State its colour. Predict what you would expect to observe when solid Na_2CO_3 is added to an aqueous solution of this ion.

6) Give one use of the metal V.

7) What would you **observe** when a green coloured aqueous solution of $CrCl_3$ is subjected to the following?
   I. Addition of a few drops of dilute NaOH
   II. Additions of excess dilute NaOH followed by H_2O_2, and then heated.

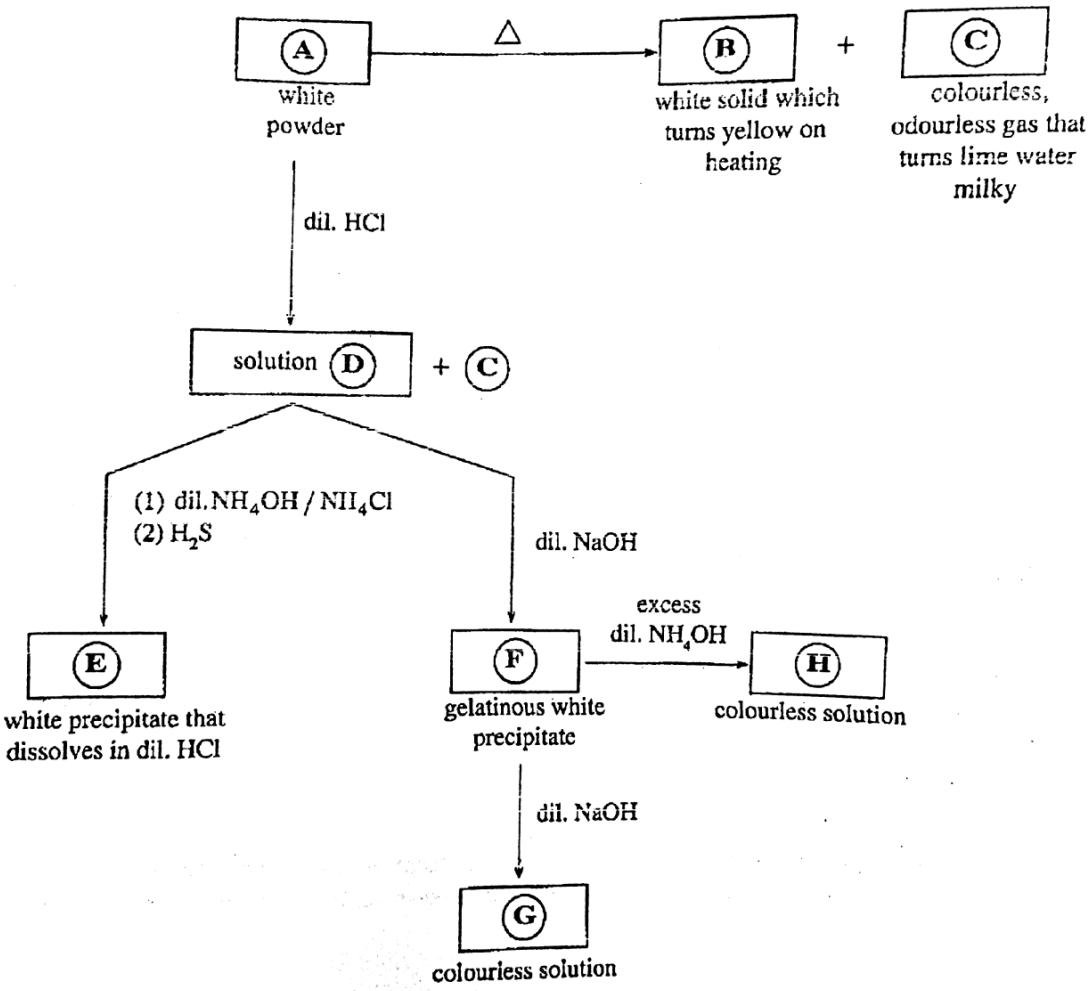
8) When a concentrated solution of K_2Cr_2O7 is treated with conc. H_2SO_4, the bright red acidic oxide **X** of chromium is precipitated. On heating **X**, the green amphoteric oxide **Y** is obtained. **Y** could also be obtained on heating $(NH_4)_2Cr_2O_7$. Give the chemical formulae of **X** and **Y**.

9) What would you observe when dil. NaOH is added to a solution of $K_2Cr_2O_7$?

10) Give **one** advantage and **one** disadvantage of using $K_2Cr_2O_7$ in titrations.

Question 50 – (2013)

Reactions of compounds of an element in the 3d block of the Periodic Table are given below.
Identify the species **A,B,C,D,E,F,G** and **H**



Question 51– (2016)

(*a*) The compound **A** (**A** = MX_n, M = a transition element that belongs to the 3*d*-block, X = ligands of the same type) when treated with excess dilute NaOH followed by H_2O_2 gives a compound **B**. When an aqueous solution of **B** is acidified with dil. H_2SO_4 compound **C** is produced. **C** when reacted with NH_4Cl gives compound **D** as one of the products. Heating solid **D** gives a blue coloured compound **E**, water vapour and an inert diatomic gas **F**. Ca metal when burnt in gas **F** gives a white solid **G**. The reaction of **G** with water liberates a gas **H**. This gas forms white fumes with HCl gas. The metal Na reacts with liquid **H** to give a colourless diatomic gas **I** as one of the products. When an aqueous solution of **A** is treated with excess Na_2CO_3, a coloured precipitate is formed. The precipitate is filtered and the filtrate is acidified with dil HNO_3. Addition of $AgNO_3$(aq) to this solution gives a white precipitate which is soluble in dilute NH_4OH.

(i) Identify **A**, **B**, **C**, **D**, **E**, **F**, **G**, **H** and **I**.

(ii) What will you observe when a solution containing **C** is treated with dil. NaOH? Give the balanced chemical equation relevant to this observation.

(*b*) An aqueous solution **T** contains **three** metal ions. The following experiments were carried out to identify these metal ions.

Experiment	Observation
1. **T** was acidified with dilute HCl, and H_2S was bubbled through the clear solution obtained.	A black precipitate $\mathbf{Q}_1$ was formed.
2. $\mathbf{Q}_1$ was removed by filtration. The filtrate was boiled till all the H_2S was removed. The solution was cooled, and NH_4Cl and NH_4OH were added. H_2S was bubbled through the solution.	A clear solution was obtained. A black precipitate $\mathbf{Q}_2$ was formed.
3. $\mathbf{Q}_2$ was removed by filtration. The filtrate was boiled till all the H_2S was removed, and a solution of $(NH_4)_2CO_3$ was added.	A white precipitate $\mathbf{Q}_3$ was formed.

Experiments for precipitates $\mathbf{Q}_1$, $\mathbf{Q}_2$ and $\mathbf{Q}_3$.

Experiment	Observation
1. $\mathbf{Q}_1$ was dissolved in hot dilute HNO_3. After cooling, the solution was neutralized and KI was added.	A precipitate and a brown solution were formed.
2. $\mathbf{Q}_2$ was dissolved in warm dilute HCl. The solution was cooled, and dilute NH_4OH was added. More dilute NH_4OH was added to this mixture.	A green precipitate was formed. The green precipitate dissolved giving a deep blue solution.
3. $\mathbf{Q}_3$ was dissolved in conc. HCl and the solution was subjected to the flame test.	A green flame was obtained.

(i) Identify the **three** metal ions in solution **T**. **(Reasons are not required.)**

(ii) Write the chemical formulae of the precipitates $\mathbf{Q}_1$, $\mathbf{Q}_2$, and $\mathbf{Q}_3$.

(5.0 *marks*)

Question 52– (2017)

(*b*) An aqueous solution **Q** contains **three** anions. The following tests were carried out to identify these anions. (Fresh portions of solution **Q** were used for each test ① to ⑤).

		Test	Observation
①	I	Dilute HCl was added.	A colourless gas was evolved. A clear solution was obtained.
	II	The gas evolved was tested with filter paper moistened with lead acetate.	No colour change
②	I	A $BaCl_2$ solution was added.	A white precipitate was obtained.
	II	The white precipitate was separated by filtration, and dil. HCl was added to it.	The white precipitate dissolved with the evolution of a gas.
	III	The gas evolved was tested with a filter paper moistened with acidified potassium dichromate.	The colour changed from orange to green.
③		Conc. HNO_3 and an excess of ammonium molybdate solution were added and the mixture was warmed.	A yellow precipitate did not form.
④		Devarda's alloy and NaOH solution were added and the mixture was heated.	A gas that turned Nessler's reagent brown was evolved.
⑤		A $FeCl_3$ solution was added.	A blood red coloured solution was obtained.

(i) Identify the **three** anions in solution **Q**.

..... , ... and .....

(ii) Write the balanced chemical equation for the reaction taking place in test number ② III.

.....

(5.0 *marks*)

Question 53– (2018)

(*a*) **A** and **B** are **complex ions**, (i.e. metal ion and ligands coordinated to it) with an octahedral geometry. They have the same atomic composition of $MnC_5H_3N_6$. In each complex ion, **two** types of ligands are coordinated to the metal ion. When an aqueous solution containing **A** is treated with a potassium salt, the **coordination compound C** is formed. **C** gives four ions in aqueous solution. When an aqueous solution containing **B** is treated with a potassium salt the **coordination compound D** is formed. **D** gives three ions in aqueous solution. Both **C** and **D** have an octahedral geometry.

(**Note**: The oxidation states of manganese in **A** and **B** do not change on treatment with the potassium salt).

(i) Identify the ligands coordinated to manganese in **A** and **B**.

(ii) Give the structures of **A**, **B**, **C** and **D**.

(iii) Write the electronic configurations of the manganese ions in **A** and **B**.

(iv) Write the IUPAC names of **C** and **D**.

Question 54– (2022)

(*b*) (i) **X** is a *d*-block element that belongs to the fourth period of the Periodic Table. On reacting **X** with dil. HCl, the colourless solution $\mathbf{X_1}$ and the gas $\mathbf{X_2}$ are obtained. When $\mathbf{X_1}$ is treated with dil. NH_4OH/NH_4Cl and H_2S is bubbled through the solution thereafter, the white precipitate $\mathbf{X_3}$ is obtained. $\mathbf{X_3}$ is soluble in dil. HCl. On addition of dil. NaOH to $\mathbf{X_1}$, the gelatinous white precipitate $\mathbf{X_4}$ is formed. $\mathbf{X_4}$ dissolves in excess dil. NaOH and in excess dil. NH_4OH to give $\mathbf{X_5}$ and $\mathbf{X_6}$ respectively. Both $\mathbf{X_5}$ and $\mathbf{X_6}$ are colourless.

I. Identify the species **X** and $\mathbf{X_1}$ to $\mathbf{X_6}$. (Give chemical formulae) **Note**: Reasons are not required.

II. Write the electronic configuration of **X**.

III. Explain why $\mathbf{X_1}$ is colourless.

IV. Write the IUPAC name of $\mathbf{X_6}$.

(ii) **Y** is also a *d*-block element that belongs to the same row as **X** in the Periodic Table. **Y** has two common oxidation numbers **n** and **m**. **m** is greater than **n**. $\mathbf{Y^{n+}}$ forms the pink coloured species $\mathbf{Y_1}$ in aqueous solution. On treatment of the solution containing $\mathbf{Y_1}$ with dil. NaOH the pink precipitate $\mathbf{Y_2}$ is formed. When H_2S is bubbled through a slightly basic solution containing $\mathbf{Y_1}$, the black precipitate $\mathbf{Y_3}$ is obtained. The yellowish-brown species $\mathbf{Y_4}$ is formed on addition of excess conc. ammonia to a solution containing $\mathbf{Y_1}$. On treatment of a solution containing $\mathbf{Y_1}$ with conc. HCl, the blue coloured species $\mathbf{Y_5}$ is obtained. On exposure of $\mathbf{Y_4}$ to air, the brownish-red species $\mathbf{Y_6}$ is formed.

I. Give the values of **n** and **m**.

II. Identify the species **Y** and $\mathbf{Y_1}$ to $\mathbf{Y_6}$. (Give chemical formulae) **Note**: Reasons are not required.

III. Write the electronic configurations of $\mathbf{Y^{n+}}$ and $\mathbf{Y^{m+}}$.

IV. Write the IUPAC name of $\mathbf{Y_5}$. ***(75 marks)***

(*a*) An aqueous solution **P** contains **two** cations and **two** anions. The following experiments were carried out to identify these cations and anions.

Cations

	Experiment	Observation
①	**P** was acidified with dilute HCl and H_2S was bubbled through the solution.	A clear solution was obtained.
②	The above solution was boiled till all the H_2S was removed. A few drops of conc. HNO_3 were added and the solution was heated further. The resulting solution was cooled and NH_4Cl/NH_4OH was added.	A brown precipitate (**Q**) was formed.
③	**Q** was removed by filtration and H_2S was bubbled through the filtrate.	A pale pink precipitate (**R**) was formed.
④	**R** was removed by filtration and the filtrate was boiled till all the H_2S was removed. $(NH_4)_2CO_3$ was added to the solution.	A clear solution was obtained.
⑤	Dilute NaOH was added to a **fresh portion** of **P**.	A dirty-green precipitate and a while precipitate were formed.

Experiments for precipitates **Q** and **R**:

	Experiment	Observation
⑥	**Q** was dissolved in dil. HNO_3 and a salicylic acid solution was added.	A light purple solution was obtained.
⑦	**R** was dissolved in dilute acid and dil. NaOH was added to the solution.	A white precipitate was formed. It turned brown on standing.

Anions

		Test	Observation
⑧	I.	$BaCl_2$ solution was added to **P**.	A white precipitate was formed.
	II.	The white precipitate was separated by filtration and dil. HCl was added to the precipitate.	The white precipitate was not dissolved.
⑨		Cl_2 water and chloroform were added to a portion of the filtrate from ⑧ II, and the mixture was throughly shaken.	Chloroform layer turned yellowish-brown.

(i) Identify the **two** cations and the **two** anions in solution **P**. (Reasons are **not** required.)

(ii) Write the chemical formulae of the precipitates **Q** and **R**.

(iii) Give reasons for the following:

I. Removal of H_2S in experiment ② for cations.

II. Heating with conc. HNO_3 in experiment ② for cations.

(7.5 *marks*)

Question 55– (2019)

(*a*) Solution **Y** contains **three** cations.

Ⓐ The following tests were carried out to identify these cations.

	Test	Observation
①	Dilute HCl was added to a small portion of **Y**.	A white precipitate ($\mathbf{P}_1$)
②	$\mathbf{P}_1$ was separated by filtration and H_2S was bubbled through the solution.	A black precipitate ($\mathbf{P}_2$)
③	$\mathbf{P}_2$ was separated by filtration. The filtrate was boiled to remove the H_2S, cooled, and NH_4OH/NH_4Cl was added.	No precipitate
④	H_2S was bubbled through the solution.	A black precipitate ($\mathbf{P}_3$)

Ⓑ The following tests were carried out for precipitates $\mathbf{P}_1$, $\mathbf{P}_2$ and $\mathbf{P}_3$.

Precipitate	Test	Observation
$\mathbf{P}_1$	I. Water was added to $\mathbf{P}_1$ and the mixture was boiled.	**Part** of $\mathbf{P}_1$ dissolved.
	II. The mixture from I above was filtered while warm and the following tests were carried out on the filtrate ($\mathbf{F}_1$) and residue ($\mathbf{R}_1$).	
	Filtrate ($\mathbf{F}_1$)	
	• Dilute H_2SO_4 was added to warm $\mathbf{F}_1$.	A white precipitate
	Residue ($\mathbf{R}_1$)	
	• $\mathbf{R}_1$ was washed thoroughly with warm water and dilute NH_4OH was added.	$\mathbf{R}_1$ dissolved.
	• Thereafter, a KI solution was added.	A dark yellow precipitate
$\mathbf{P}_2$	$\mathbf{P}_2$ was dissolved in warm dil. HNO_3 and a potassium chromate solution was added.	A yellow precipitate
$\mathbf{P}_3$	I. $\mathbf{P}_3$ was dissolved in warm conc. HNO_3.	A pink coloured solution **(solution 1)**
	II. The following were added to **solution 1** above.	
	• conc. HCl	A blue coloured solution **(solution 2)**
	• dil. NH_4OH	A yellow-brown coloured solution **(solution 3)**

(i) Identify the **three** cations. (Reasons are **not** required.)

(ii) Identify,

I. precipitates $\mathbf{P}_1$, $\mathbf{P}_2$ and $\mathbf{P}_3$

II. species responsible for the colours of **solutions, 1, 2** and **3**.

(**Note:** Write chemical formulae **only**.)

(iii) Explain **briefly** why the cation/s that precipitate/s in Ⓐ ④ above does not/do not precipitate in acidic medium. ***(7.5 marks)***

(i) $TiCl_3$ is a violet coloured solid. In water, two hydrated species of $TiCl_3$, **A** and **B** are formed. **A** and **B** are coordination compounds of titanium with an octahedral geometry, containing H_2O and Cl^- as ligands.

A and **B** were separated and their atomic compositions were determined. The compounds were further analysed using the procedures given below.

Analysis of A

When excess $AgNO_3(aq)$ was added to 50.00 cm^3 of a 0.20 mol dm^{-3} solution of **A**, a white precipitate that was soluble in dilute ammonia was obtained. The mass of the precipitate after washing and oven drying (to a constant mass) was 4.305 g.

Analysis of B

When excess $AgNO_3(aq)$ was added to 50.00 cm^3 of a 0.30 mol dm^{-3} solution of **B**, the same white precipitate was obtained as in analysis, **A**. The mass of the precipitate after washing and oven drying (to a constant mass) was also 4.305 g.

(H = 1, O = 16, Cl = 35.5, Ti = 48, Ag = 108)

I. Write the electronic configuration of titanium in **A** and **B**.

II. Deduce the structures of **A** and **B**.

III. Give the IUPAC names of **A** and **B**.

(ii) **X**, **Y** and **Z** are coordination compounds of the metal ion **M**(II). They have a square planar geometry. **X** is a neutral compound. On addition of $BaCl_2(aq)$ to an aqueous solution of **Y**, a white precipitate that is insoluble in dilute acids is obtained. **Z** gives three ions in aqueous solution.

Write the structural formulae of **X**, **Y** and **Z** selecting the appropriate species from the list given below.

K^+, NH_3, CN^-, SO_4^{2-}

(7.5 marks)

Question 56– (2020)

(*a*) **A, B, C** and **D** are chlorides of *p*-block elements. These elements have atomic numbers less than 20. A description of the products ($\mathbf{P_1}-\mathbf{P_9}$) formed when **A** is reacted with a limited amount of water and **B, C** and **D** are reacted with excess water are given below.

Compound		Description of products
A	$\mathbf{P_1}$	a compound with a covalent network structure
	$\mathbf{P_2}$	a strong monobasic acid
B	$\mathbf{P_3}$	a gas that turns red litmus blue
	$\mathbf{P_4}$	a compound with bleaching properties
C	$\mathbf{P_5}$	a tribasic acid
	$\mathbf{P_6}$	a strong monobasic acid
D	$\mathbf{P_7}$	a gas that turns acidic $KMnO_4$ solution colourless
	$\mathbf{P_8}$	a colloidal solid
	$\mathbf{P_9}$	a strong monobasic acid

(i) Identify **A, B, C** and **D** (give the chemical formulae).

A: ..... **B**: ..... **C**: ..... **D**: .....

(ii) Give balanced chemical equations for the reactions of **A, B, C** and **D** with water to give products $\mathbf{P_1}$ to $\mathbf{P_9}$.

(iii) Write balanced chemical equations for the following reactions.

I. $\mathbf{P_1}$ with NaOH(aq)

.....

II. $\mathbf{P_3}$ with Mg

.....

III. $\mathbf{P_7}$ with acidic $K_2Cr_2O_7$

.....

(50 *marks*)

(*b*) A student is provided with bottles labelled **P, Q, R, S, T** and **U** containing aqueous solutions of $Al_2(SO_4)_3$, H_2SO_4, $Na_2S_2O_3$, $BaCl_2$, $Pb(Ac)_2$ and KOH **(not in order)**. Some useful observations for their identification on mixing two solutions at a time are given below. (Ac - Acetate ion)

	Solutions mixed	**Observations**
I	**T + R**	a clear colourless solution
II	**P + R**	a white precipitate
III	**T + S**	a gelatinous white precipitate
IV	**U + R**	a white precipitate
V	**P + Q**	a white precipitate, turns black on heating
VI	**P + U**	a white precipitate, dissolves on heating

(i) Identify **P** to **U**.

P: ..... **Q**: ..... **R**: .....

S: ..... **T**: ..... **U**: .....

(ii) Give balanced chemical equations for each of the reactions **I** to **VI**.

I: .....

II: .....

III: .....

IV: .....

V: formation of white precipitate: .....

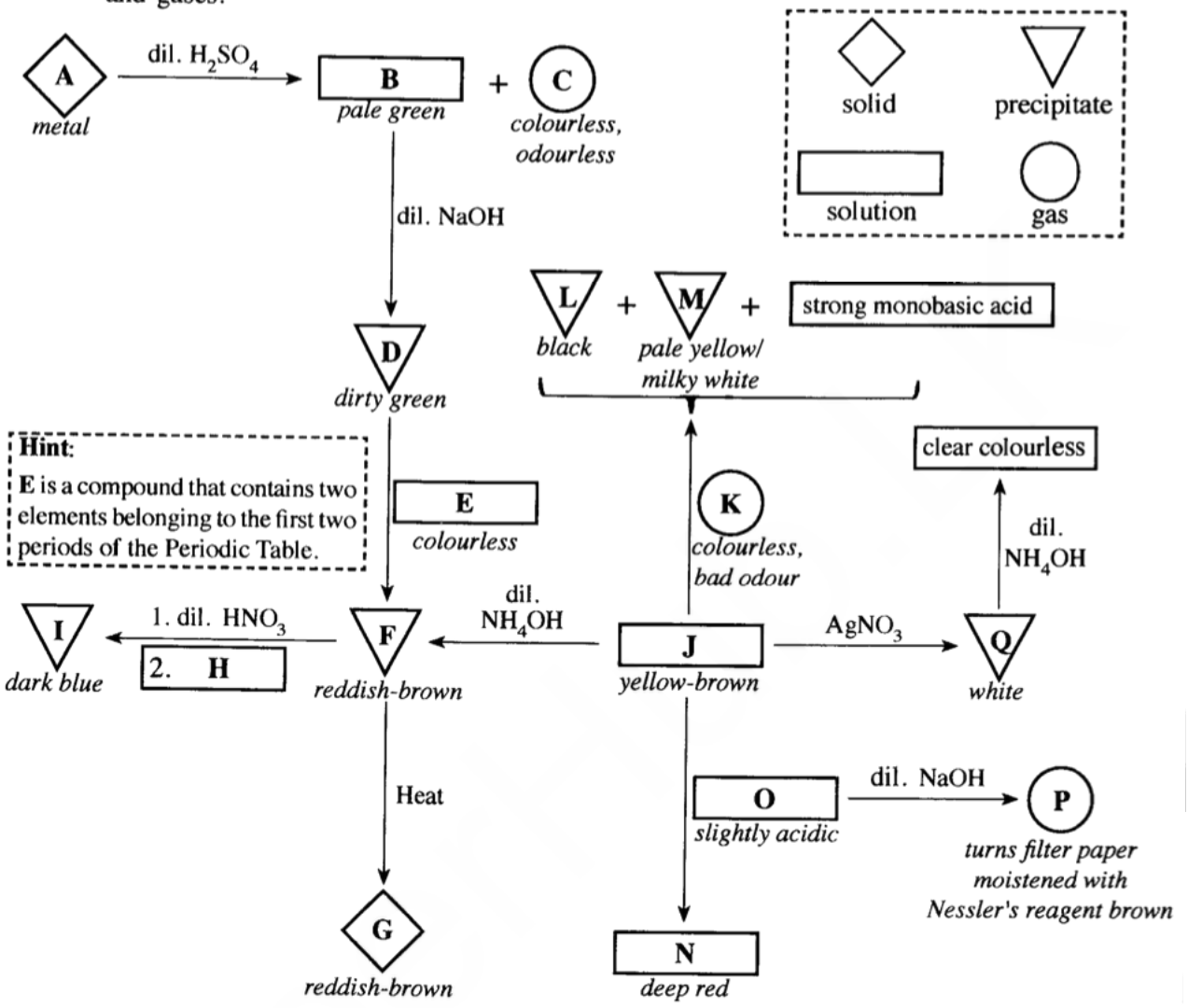
turning black on heating: .....

VI: .....

(**Note**: indicate precipitates as ↓)

(50 *marks*)

(a) (i) Write the chemical formulae of the substances **A – Q** given in the flow chart below.
(**Note**: Chemical equations and reasons are not expected for the identification of substances **A – Q**.)
The symbols given in the box (dash lines) are used to represent solids, precipitates, solutions and gases.



(ii) Write the complete electronic configuration of **A**.

(iii) State the function of **E** in the conversion of **D** to **F**. Give the relevant balanced chemical equations for the stated function.

(75 *marks*)

57. **M** has a cation and that cation forms a blue colour solution with conc. HCl .

1 .Write the chemical symbol of **M**.

2 .Write the complete electronic configuration of **M**.

3. Which oxidation state is the most likely to exist considering the electron configuration to **M**.

4. How would an aqueous solution containing cation in the stable lowest oxidation state of **M** react with aqueous NaOH.

5. Under the certain conditions, the reactions between aqueous NH_3 and an aqueous solution containing cation at the lowest oxidation state of **M** appear to be different from the reaction in (4) above. How do you explain it using a balanced chemical equation?

6 .Write the formula of chemical species responsible for the blue colour of **M**.

7. Write the observations and the reason when excess water was added to the chemical species of blue colour **M**.

58. **A** is a coloured inorganic salt containing metallic element of **M**.

When **A** is heated to give a green residue called B =(M_2O_3),a colourless gas called **C** and water vapor is consumed 1 mol of **A** gives 1 mol of **B** residue. **C** gas reacts with dissolved Mg to form a white solid **D**.

D reacts with water to give a gas **E** which turns red litumas to blue. When **A** was heated with Na_2CO_3 and then **E** gas was formed. When green coloured **B** was heated with basic H_2O_2 solution gave a yellow colour solution **F**.

1. Name **A**, **B**, **C**, **D**, **E** and **F**.
2. Write balanced chemical equations for each reactions.

59. An orange crystaline substance **A** was heated to give a green residue **B** and a colourless and odorless gas **C**. When a piece of Mg was burned with **C** gas to give white precipitate **D**. Then water was added to **D** gas was released which turned brown on a filter paper moistened with Nessler's reagent. Residue **B** was heated with base and $KClO_3$ to give a yellow solution **F**, which on acidification turned orange to give **G**.

1. Identify **A**, **B**, **C**, **D**, **E**, **F** and **G**

2. Write the balanced chemical equations.

60. A white substance reacted with dil.H_2SO_4 to give colourless **B** gas and colourless solution. When **B** was treated with $K_2Cr_2O_7$ gives precipitate and turns into a green coloured **D** solution. A substance **E** when burned in air gave a gas **F** and this gas reacted with **B** to give yellow coloured **E** and a colourless liquid. This colourless liquid turned blue when added to anhydrous $CuSO_4$,dissolved in excess of NH_3 to give **G**.

1. Identify **A**, **B**, **C**, **D**, **E**, **F** and **G**.
2. Write the all balanced chemical equations .

61. If one drop of conc. NH_3 is added to a solution of Chromium (III) sulphate given a green colour precipitate **A**. **A** got precipitated in excess aqueous ammonia and given a green colour. **A** precipitated aqueous NaOH and dissolves in excess NaOH to give a green colour solution **C**. When H_2O_2 was added to **C** , given a yellow colour solution called **D**. When dilute H_2SO_4 was added to **D**, given **E** and turned to orange .

Identify **A**, **B**, **C**, **D**, **E**, **F** and **G** .

62. **L** and **M** are 3d trasitional elements. **L** is a tetrahedral oxyanion. **M** forms M^{+2} cation one mole of **L** (oxyanion) is reacted with 5 mol of $\mathbf{M^{+2}}$ and oxide to $\mathbf{M^{+3}}$ and forms $\mathbf{L^{+2}}$. $\mathbf{M^{+3}}$ is a yellowish-brown coloured aqueous and it release I_2 from KI.

1. Write the oxidation state of oxyanion of **L**.

2.What the elements of **L** and **M**.

3.Write the formula of oxyanion (**L**)

4.Give the reductant and the reaction in the industrial process used to convert M_2O_3 to M.

5.Give a reaction useful $L(OH)_2$ in quantitative analysis.

63. Labels of bottles containing aqueous solutions of KI, H_2O_2, $FeCl_3$ and $K_3[Fe(CN)_6]$ have come off. In an attempt to identify these solutions, they were named **A**, **B**, **C** and **D**.Two solutions were mixed separately in test tubes as follows. Each mixture obtained , was acidified and shaken with CH_3Cl.The colours of the CH_3Cl layers are show below.

Test 1, 2, 3, 4 were done by mixing solutions in the order (1) A+C, (2) B+C, (3) C+D, (4) B+D

Colour of $CHCl_3$ layer colourless, colourless, colourless, purple

When **A** is added to the mixture of (4) test dark blue precipitate is formed in aqueous layer. Identify the solution in the bottle of **A**, **B**, **C** and **D**. Give the reasons

64.There are two elements **A** and **B** in a mixture as their sulphides.

Inspections.

1. Mixture was dissolved in dil. HCl, added few drops of conc. HNO_3 and heated untill the gas is completely released.

2. NH_4Cl and excess NH_4OH were added to (1) solution

3. Precipitate of (2) was washed with water, dissolved in dil. HCl and shaken with KI and $CHCl_3$.

4. $(NH_4)_2\ CO_3$ was added to the filterate of the (2) above .

5. Precipitate of (4) was dissolved in dilute acitic acid and treated with K_2CrO_4.

Observations (after each inspections)

1. A clear solution was obtained by cooling.

2. A precipitate was obtained

3. The $CHCl_3$ layer turned to purple colour.

4. A white precipitate was formed.

5. A yellow precipitate formed.

Identify **A** and **B** by giving observations from each of inspections .

65. Following test and observations are from **S** solution which containing two chlorides of 3d transitional elements.

Tests.

a) Aqueous NaOH was added to **S** solution

b)The **S** solution was heated with aqueous NaOH and H_2O_2 and filtered.

c) Con.HCl was added to the precipitate of (b)

d) Yellow solution which obtained from (c) was diluted and gaseous H_2S was passed.

Observations

1. A blue-green precipitate was obtained .

2. A precipitate and a yellow filtrate were obtained.

3. Yellow coloured solution was obtained

4. A Black precipitate was obtained.

1. Give the cations containing in **S** solution
2. The ion which gives yellow colour to filtered solution of (b).
3. The ion which obtained a yellow solution in (c). Write the balanced chemical equations caused for obtained yellow colour.

4. Give the observations when acidic the filtrate (b) solution .

66. Following tests and observations are salt of **X**. Tests

A. **X** was heated with dil. HCl

B. H_2S was passed through **X** solution

C. A solution of **X** in dil. HCl was diluted with water.

D. **X** was heated from NaOH

E. **X** was heated with NaOH solution and Al powder .

Observations

1. Colourless solution was formed.

2. An orange colour precipitate was formed.

3. A white coloured precipitate was gradually formed.

4.No liberation of gases

5. Ammonia was released.

1.Write observations for each of tests

2. Identify the **X** salt

3. Give another test to confirm the identity of the anion.

67. **A**, element belongs to the S block. It has the highest first ionization energy in that group. **A** reacts with water and gas **B** is released. This solution gives a red colour to the Bunsen flame and on evaporation gives a metal oxide.

The metal reacts with N_2 to produce compounds **C** and **D**. **C** gives a basic compound when dissolved in water. The same compound **E** is fromed when **D** was treated with water. It releases a gas **E** which turns red litmus blue.

1. Identify **A**, **B**, **C**, **D** and **E** by giving their chemical formulas .
2. Give balanced chemical equations for reactions include in above.

68. Concentrated HCl acid was gradually added to the solid $CuCO_3$.

1. Write clearly 3 changes you would expected to observe above.
2. Write the observations that can be obtained by diluting the above solution with water.

3. Write the observations that can be obtained by adding one drop of ammonia per part of the dilute solution .

4. Write the observations that maybe obtained on passing H_2S to the remainder of dilute solution .

69. The following inspections and observations made for compound **D**.

Inspections:

1. dil.HCl was added to the salt.

2. Part of the gas was passed through lime water and the other part through an acidic $K_2Cr_2O_7$ solution.

3. KSCN was added to the solution obtained in test 1 above.

4.Excess ammonia was added to the 3rd test.

5. After shaking the precipitate from 4 with H_2O_2 dil.H_2SO_4 was added .

Observations

1. Colourless gas was released. Light green solution was obtained .

2. The lime liquid turned milky and the colour of of acidic $K_2Cr_2O_7$ turned green.
3. No colour change.
4. A dirty green precipitate was formed.
5. A dark red solution was formed.

Identify the **D**.

70. The following tests and observations made for compound **A**.

Tests

1. dil.HCl was added to the salt
2. excess NaOH and H_2O_2 were added to the solution which in (1) test.

3.$Pb(CH_3COO)_2$ was added to the solution which obtained by (2)

4 dil. CH_3COOH was added to the precipitate from (3) test.

Observations

1. brown coloured gas was released. Green colour solution was obtained.

2. Yellow coloured solution was obtained.
3. Yellow colour precipitate was obtained.
4. Yellow colour precipitate didn't dissolve.

Identify the **A**.

71. The following tests and observations made for compound **B**.

Tests

1. dil. HCl was added to the salt.
2. Part of the gas was passed through lime water and another part through an acidic $K_2Cr_2O_7$.

3. H_2S was passed through a portion of the solution obtained in experiment 1 above.

4. Water was added to the remainder of the solution obtained in test 1 above.

Observations

1. A colourless gas was released. A colourless solution was obtained.

2. Lime water was turned to milky. Acidic $K_2Cr_2O_7$ was turned to green.

3. Black coloured precipitate was formed.

4. A white precipitate was formed.

72. The following inspections and observations for compound **C**.

Inspections

1. Dilute HCl was added to the salt
2. A filter paper moistened with $Pb(CH_3COO)_2$ was exposed to the gas.

3.H_2S sent through part of the solution obtained from (1)test
4. Excess ammonia was added to the other part of solution from (1)

Observations

1. A colourless gas was released. A colourless solution was formed.

2. Filter paper turned black in colour.
3. No appreciable change.
4. Dark blue solution was obtained.

Identify the **C** compound.

IUPAC Nomenclature of Coordination Complexes

(01) Write the IUPAC names of the following compounds.

i. Mg_3N_2 - …….....

ii. $FeCl_3$ - …….....

iii. $Na_2Cr_2O_7$ - …….....

iv. $(NH_4)_2Cr_2O_7$ - …….....

v. $Ni(MnO_4)_2$ - …….....

(02) Write the IUPAC names of the following ions.

i. $[CuCl_4]^{2-}$ - ……

ii. $[CoCl_4]^{2-}$ - ……

iii. $[Fe(CN)_6]^{4-}$ - …….....

iv. $[Co(CN)_6]^{3-}$ - …….....

v. $[Fe(CN)_6]^{3-}$ - …….....

vi. $[Ag(CN)_2]^{-}$ - …….....

vii. $[Cr(Br)_6]^{3-}$ - ……

viii. $[Fe(H_2O)_6]^{2+}$ - ……

ix. $[Cr(H_2O)_6]^{3+}$ - ……

x. $[Cr(H_2O)_2(NH_3)_4]^{3+}$ - ……

xi. $[Co(OH)(NH_3)_4(H_2O)]^{2+}$- ……

xii. $[Co(CN)_2(NH_3)_4]^{+}$ - ……

xiii. $[Fe(CN)_2(NH_3)_4]^{+}$ - ……

xiv. $[Fe(CN)_5NO]^{3-}$ - ……

xv. $[CoCl(NH_3)_5]^{2+}$ - ……

(03) Write the IUPAC names of the following coordination complexes.

i. $K_4[Fe(CN)_6]$ - …….....

ii. $K_3[Fe(CN)_5(NO)]$ - …….....

iii. $Na_2[ZnCl_4]$ - …….....

iv. $[Fe(SCN)_2]_2S$ - ……..

v. $[CrCl_2(H_2O)_4]_2CrO_4$ - …….

vi. $[Ag(NH_3)_2]Cl$ - …….

vii. $[Fe(OH)_2(H_2O)_4]Br$ - …….

viii. $[CoCl(NH_3)_5](NO_3)_2$ - …….

ix. $[CoCl(NH_3)_5](NO_2)_2$ - …….

x. $K_2[CuCl_4]$ -……..

xi. $[Cr(NH_3)_6][Fe(CN)_6]$ - …….

xii. $[Co(SO_4)(NH_3)_4]NO_3$- …….

xiii. $Al[Ag(CN)_2]_3$ - …….

xiv. $[Al(CN)_2]_2[CuF_4]$ - …….

xv. $[Fe(SCN)][CuCl_4]$ - ……..

(04) Write the chemical formulae of the following complexes.

i. Ammonium hexacyanoferrate (III) - ……..

ii. Tetraamminecopper (II) bromide - ……..

iii. Potassium hexacyanoferrate (III) - ……..

iv. Hexaamminecobalt(IV) tetrachlorocuprate(II) - ……..

v. Iron (III) hexacyanoferrate (II) - ……..

vi. Tetraaquadichlorochromium (III) dichromate - ……...

vii. Dithiocyanatoiron (III) manganate (VII) - ……

viii. Hexaaquanickel (II) tetrachlorocobaltate (II) - ……

ix. Diamminebromidodicarbonylhydridocobalt(III) chloride - ……

x. Pentaamminehydroxocobalt(III) nitrate - ……