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525/1

S6 CHEMISTRY

Exam 28

PAPER 1

DURATION: 2 HOUR 45 MINUTES

Instructions:

- This paper consists of two sections A and B
- Section A is compulsory.
- Attempt **only six** questions in section B
- Answers must be written in the spaces provided **only**

For Examiner's Use Only																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

SECTION A
(**All questions are compulsory)**

1. (a) The freezing point depression of a solution containing 3.294g of sulphur in 100g of naphthalene was found to be 0.830^{o}C and another solution containing 1.67g of iodine in the same mass of naphthalene has freezing point depression of 0.84^{o}C.
Calculate

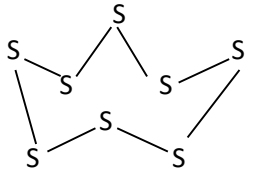
(i) The freezing point depression constant for naphthalene
(Molar mass of iodine is 127) (02 marks)

Solution
Mass of iodine in 1000 g of naphthalene
100g of naphthalene contain 1.67g
1000g of naphthalene contain $\frac{1.67\ x\ 1000}{100}$ = 16.7g

Freezing point constant of naphthalene
16.7 g of naphthalene cause a freezing point depression of 0.84
127g of iodine cause freezing point depression constant of = $\frac{127\ x\ 16.7}{16.7}$ = 6.388^{0}mol^{-1}kg^{-1}

(b) (i) Determine the molecular formula of Sulphur. (1 ½ marks)
The molar mass of sulphur in naphthalene.
Mass of sulphur in 1000g of naphthalene
100g of naphthalene contain 3.294g
1000g of naphthalene contain $\frac{3.294\ x\ 1000}{100}$ = 32.94g
Molar mass of sulphur
0.83^{0} is caused by 32.94g
6.388^{0}C is caused by $\frac{32.94\ x\ 6.388}{0.83}$ = 254g

(ii) Draw the structure of sulphur. (01 mark)



2. (a) Complete the following equations

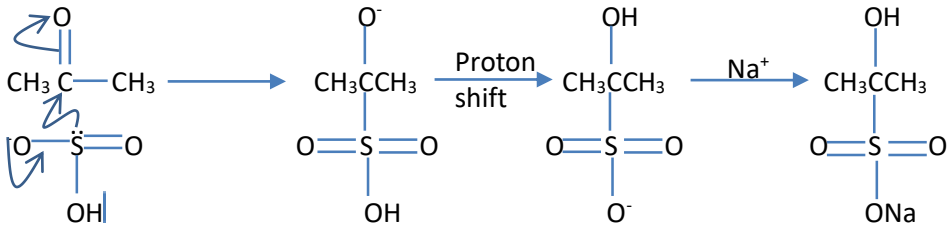
(i) $HC \equiv CH \xrightarrow[Na \text{ in liquid } NH_3]{CH_3Br} HC{\equiv}CCH_3$

(ii) $CH_4 + H_2O \xrightarrow[\text{Heat } (900^oC)]{Ni} CH_3OH$

(iii) $CH_3CH_2CH_2Cl \xrightarrow[\text{ethanol (reflux)}]{Cu - Zn} CH_3CH_2CH_2\text{-}CH_2CH_2CH_3$

(iv) $CH_3COCH_3 \xrightarrow{NaHSO_3} (CH_3)_2C(OH)SO_3Na$

(b) Write the mechanism for the reaction in (iv) (02 marks)



3. (a) State three properties in which carbon differs from the rest of group (iv) elements. (1 ½ marks)

- Form gaseous oxides
- Forms compound I oxidation state 4 only
- Its halides do not hydrolyze in water
- Form compound with long carbon chains
- Form compounds multiple bond between carbon atoms and other elements

(b) Write equations for the reaction between concentrated sulphuric acid and

(i) carbon

Equation

$C(s) + 2SO_4^{2-}(aq) + 4H^+(aq) \rightarrow CO_2(g) + SO_2(g) + 2H_2O(l)$

(ii) Tin

Equation

$Sn\ (s) + 2SO_4^{2-}(aq) + 4H^+(aq) \rightarrow SnO_2(s) + SO_2(g) + 2H_2O(l)$

4. (a) Explain why hydrogen fluoride is a weaker acid than hydrogen chloride. (02 marks)

The H-F is stronger than H-Cl bond that H-F bond hardly ionizes to release H^+

(b) Molar conductivities at infinite dilution at 25°C for some compounds are shown on the table below.

Compound	Λ_0 (ohm $^{-1}$ m^2 mol $^{-1}$)
Nitric acid	0.0421
Potassium nitrate	0.0145
Potassium fluoride	0.0129

The conductivity of a 0.1 moldm^{-3} aqueous solution of hydrogen fluoride is 3.15 x 10^{-3} Ω^{-1} m^{-1}.

Calculate the:

(i) Molar conductivity of solution (1 ½ marks)

Concentration in molm^{-3} = (0.1 x 1000) molm^{-3}

$\Lambda c = \frac{K}{C} = \frac{3.15\ x\ 10^{-3}}{0.1\ x\ 1000}$ = 3.15 x $10^{-5}\Omega^{-1}m^2$

(ii) Degree of ionization of hydrogen fluoride. (2 ½ marks)

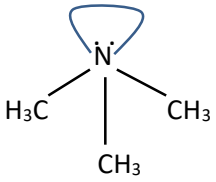
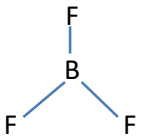
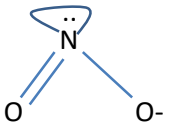
$\Lambda_0 HF = \Lambda_0 HNO_3 + \Lambda_0 KF - \Lambda_0 KNO_3$

= 0.0421 + 0.0129 - 0.0145

= 0.0405

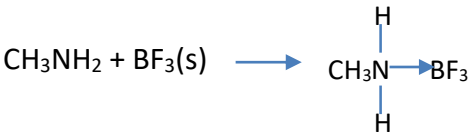
$$\alpha = \frac{\Lambda_C}{\Lambda_0} = \frac{3.15 \text{ x } 10^{-5}}{0.0404} = 0.019$$

5. (a) Draw the structures and name the shapes of the following species. (4 ½ marks)

Species	Structure	Shape
$(CH_3)_3N$		Triangular pyramidal
BF_3		Triangular planar
NO_2^-		V-shaped

(b) Write equation for the reaction between

(i) Trimethylamine and borontrifluoride



(ii) Acidified potassium manganate (VII) and nitrate ions.

$2MnO_4^-(aq) + 5NO_2^-(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5NO_3^-(aq) + 3H_2O(l)$

6. (a) Complete the following nuclear reactions and name the particles emitted in each case

(i) $^{238}_{92}U + {}^{1}_{0}n \longrightarrow {}^{239}_{93}Pu + {}^{0}_{-1}\beta$

Name of particle; beta particle

(ii) $^{241}_{95}Am + {}^{4}_{2}He \longrightarrow {}^{243}_{97}Bk + 2{}^{1}_{0}n$

Name of particle; neutron

(iii) $^{27}_{14}Si \longrightarrow ^{27}_{13}Al + \ldots\ldots$

Name of particle; ……

(b) The mass of a radioisotope, T, reduced by 32% in 40 days. Calculate the half-life of T.

Percentage of radioactive substance after 40 days = 100 – 32 = 68%

$In\frac{100}{68}$ = k x 40

$k = 0.01day^{-1}$

$t_{\frac{1}{2}} = \frac{In2}{k} = \frac{In\ 2}{0.01}$ =69days

(2 ½ marks)

7. Sulphur dioxide reacts with oxygen according to the following equation

$SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$, ΔH(– ve)

(a) State conditions for the maximum yield of sulphur trioxide. (1 ½ marks)

High pressure

Temperature 400^0 -500^0C

Catalyst; V_2O_5

(b) Write equation (s) to show the conversion of

(i) Sulphur trioxide to sulphuric acid (03 marks)

$SO_3(g) + H_2SO_4(aq) \rightarrow H_2S_2O_7(l)$

Then

$H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(aq)$

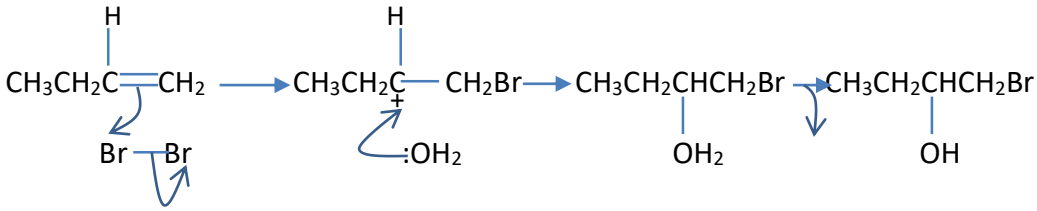
(ii) Sulphuric acid to calcium superphosphate (1 ½ marks)

$Ca_3(PO_4)_2 + 2\ H_2SO_4 + 4\ H_2O \rightarrow Ca(H_2PO_4)_2 + 2\ CaSO_4{\cdot}2\ H_2O$

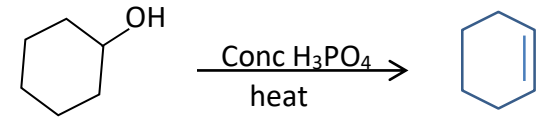
8. Complete the following reactions and write the accepted mechanism

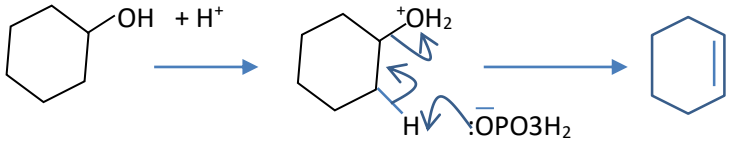
(a) $CH_3CH_2CH = CH_2$ $\xrightarrow{Br_2/H2O}$ $CH_3CH_2CH(OH)-CH_2Br$

Mechanism



(b)





9. Explain the variations of the following properties in group 2

(a) Atomic radii

Atomic radii increase down the group due to increase in the number of electron shells and screening effect.

(b) ability to form complex ions

Ability to form complex ions decreases down the group due to reduction of charge density.

(c) solubility of hydroxides

solubility of hydroxides increases down the group because down the group both lattice and hydration energies decrease but the decrease in lattice energy is bigger than the decrease in hydration energy

(d) reaction with sodium hydroxide solution

the reactivity of group 2 element with sodium hydroxide decreases down the group due to increase in metallic character. Be reacts, the rest od group 2 elements do not react with NaOH

$Be(s) + 2OH^-(aq) \rightarrow BeO_2^{2-}(aq) + H_2O(l)$

SECTION B

Attempt only **six** question

10. (a) Compare the reactivity of ethanol and phenol with phosphorus pentachloride. (Include equations for reactions if any) (03 marks)

Ethanol reacts while phenol poorly react with PCl_5 because OH group in phenol is strongly bound to benzene group.

Though **phenol** react with **PCl_5** to give **chlorobenzene,** other reagents like **HCl, $POCl_3$.**

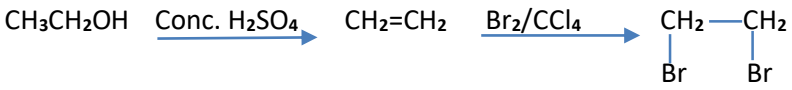
$C_6H_5OH + PCl_5 \rightarrow C_6H_5Cl + POCl_3 + HCl$

However, the yield of **chlorobenzene** is very small and the main product is **triphenyl phosphate,** which is mainly formed by the reaction between **phenol** and **$POCl_3$,**

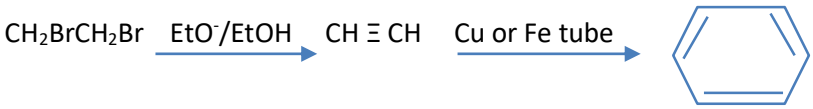
$3C_6H_5OH + POCl_3 \rightarrow (C_6H_5)_3PO_4 + 3HCl$

(b) Write equations to show how the following conversions can be effected.
(Include conditions for the reactions)

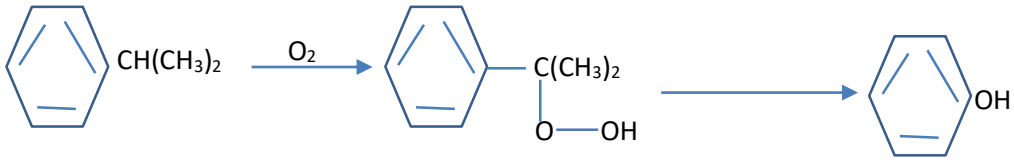
(i) Ethanol to benzene



Then,



(ii) 2 – phenyl propane to hydroxybenzene.



11. State what would be observed and in each case write equation for the reaction that would take place if

(a) Hydrogen peroxide is added to a mixture acidified barium chromate solution and ether observation

Purple color develops in ether layer.

Equation:

$2CrO_4^{2-}(aq) + 2H^+(aq) \rightarrow Cr_2O_7^{2-}(aq) + H_2O(l)$

$Cr_2O_7^{2-}(aq + 4H_2O_2(aq) + 2H^+(aq) \rightarrow 2Cr(O)_5(aq) + 5H_2O(l)$

(b) Excess chlorine is dissolved in aqueous sodium thiosulphate solution
Observation

Yellow precipitate

Equation

$S_2O_3^{2-}(aq) + Cl_2(aq) + H_2O(l) \rightarrow S(s) + SO_4^{2-}(aq) + 2Cl^-(aq) + 2H^+(aq)$

(c) Aqueous potassium iodide is added to potassium peroxodisulphate;
Observation

Solution turns brown

Equation

$2I^-(aq) + S_8O_8^{2-}(aq) \rightarrow I_2(aq) + 2SO_4^{2-}(aq)$

(d) Neutral iron (III) chloride solution is added to hydroxybenzene
Observation

Purple coloration

Equation

$3PhOH(aq) + FeCl_3(aq) \rightarrow (PhO)_3Fe(aq) + 3HCl(aq)$

12. (a) An aqueous solution containing $2.8gdm^{-3}$ of R exerts an osmotic pressure of 380mmHg at stp.
Calculate the molar mass of R (02 marks)

From $\frac{PV}{T} = Constant$ the volume (V) at stp is calculated

$\frac{380\ x\ 1}{273} = \frac{760\ x\ V}{273}$

$V = .0,5dm^3$

⇨ $0.5dm^3$ equivalent to 2.8

$22.4dm^3$ is equivalent to RFM

RFM = 125

(b) An organic compound R contains carbon, oxygen. 3.4g of R burns with a sooty flame producing 5.04 dm^3 of carbon dioxide and 2.70g of water at stp.

(i) Calculate the empirical formula of R (2 ½ marks)

Mass of carbon

22.4dm^3 of CO_2 contain 12g of carbon

5.04dm^3 of CO_2 contain $\frac{5.04\ x\ 12}{22.4}$ = 2.7g

Mass of hydrogen

18g of water 2g of hydrogen

2.7g of water contain $\frac{2.7\ x\ 2}{18}$ = 0.3g

Mass of oxygen = 3.4 – (2.7 + 0.3) = 0.4

Elements	C	H	O
Mass	2.7	0.3	0.4
RAM	12	1	16
moles	0.225	0.3	0.025
Mole ratio	9	12	1

Empirical formula = $C_9H_{12}O$

(ii) Hence determine the molecular formula of R (01 marks)

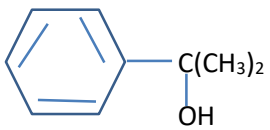
$(C_9H_{12}O)n$ = 125

n = 1

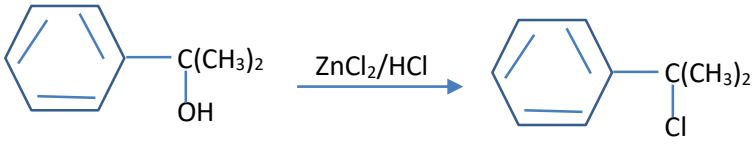
therefore molecular formula = $C_9H_{12}O$

(c) R reacts with a mixture of anhydrous zinc chloride and concentrated hydrochloric acid but does not react with acidified potassium dichromate (VII)

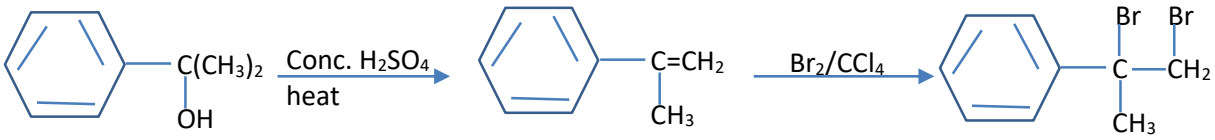
(i) Identify R (01 mark)



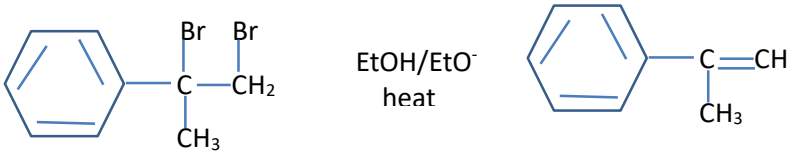
(ii) Write equation of reaction between R and a mixture of anhydrous zinc chloride and concentrated hydrochloric acid. (01 mark)



(d) Write equations to show how R can be converted to an alkene. (1 ½ marks)



Then



13. (a) Explain what is meant by the term acid-base indicator. (1 mark)
It a substance that changes color according to H^+ concentration

(b) Explain how phenolphthalein acts as an indicator. (02 marks)

The ionized and unionized forms of phenolphthalein molecule have different colors.

(c) $25cm^3$ of a solution containing a mixture of sodium hydroxide and sodium carbonate required $22.5cm^3$ of 0.1M hydrochloric acid in the presence of phenolphthalein indicator. Another $25cm^3$ of the same mixture required $36.5cm^3$ of the same acid in the presence of methyl orange indicator.
Calculate the concentration in gl^{-1} in the mixture of

(i) Sodium hydroxide (4½ marks)

Volume of acid that reacted with sodium hydroxide = 36.5 –(36.5 – 22.5) = $8.5cm^3$

Moles of hydrochloric acid that reacted with sodium hydroxide = $\frac{8.5\ x\ 0.1}{1000}$

= 0.00085moles

Moles of sodium hydroxide = moles of HCl = 0.00085 moles

Molarity of sodium hydroxide = $\frac{0.00085\ x\ 1000}{25}$ = 0.034M

Concentration of NaOH in g/l = 0.034 x 40 = 1.36g/l

(ii) Sodium carbonate

Volume of HCl the reacted with sodium carbonate =2(36.5 – 22.5)

$=28cm^3$

Moles HCl that reacted with sodium carbonate = $\frac{28\ x\ 0.1}{1000}$ =0.0028moles

Mole of sodium carbonate = ½ x moles of HCl

$= \frac{1\ x\ 0.0028}{2}$ = 0.0014 moles

Molarity of sodium carbonate = $\frac{0.0014\ x\ 1000}{25}$

$= 0.056moldm^{-3}$

Concentration of sodium carbonate in g/l = 0.056 x 106 =5.936g/l

(d) Explain why aqueous solution of sodium carbonate has a pH slightly above 7. (1½ marks)

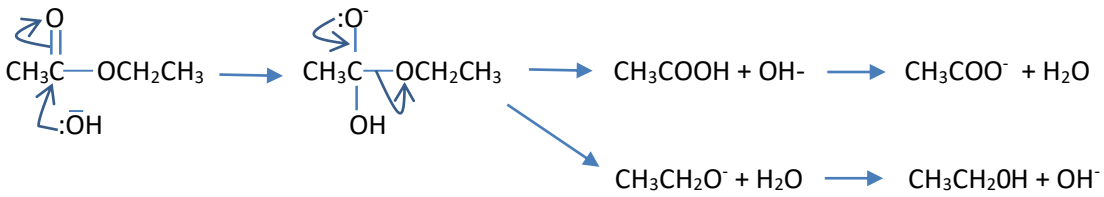
The carbonate ions hydrolyze in solution to give hydroxyl ions

$CO_3^{2-}(aq) + H_2O(l) \leftrightarrow HCO_3^-(aq) + OH^-(aq)$

14. (a) Complete the following reaction and write the accepted mechanism.

$CH_3CO_2C_2H_{5(l)} + \bar{O}H_{(aq)} \xrightarrow[\text{heat}]{H_2O}$ $CH_3COO^- + C_2H_5OH$

Mechanism



(b) The results obtained for the Kinetics of the reaction in (a) above are shown in the table below.

Expt.	$[CH_3CO_2C_2H_5]$ moldm $^{-3}$	$[\bar{O}H]$ $moldm^{-3}$	Initial rate of reaction moldm^{-3} s^{-1}
1	0.038	0.076	1.13 x 10^{-3}
2	0.038	0.152	1.13 x 10^{-3}
3	0.019	0.152	5.65 x 10^{-4}

Deduce the order of reaction with respect to

(i) $\bar{O}H$ (1 ½ marks)

Zero order

(ii) $CH_3CO_2C_2H_5$

1

(c) Write the rate equation for the reaction

Rate = $K[CH_3CO_2C_2H_5]$

(d) Calculate the rate constant (K) for the reaction and state its units. (02 marks)

$1.13 \times 10^{-3} = K(0.038)$

$K = 0.03s^{-1}$

15. The table below gives the first, second third and fourth ionization energies of elements P,Q and R

Element	Ionization energy ($kJmol^{-1}$)			
	First	Second	Third	Fourth
P	800	2,400	3,700	25,000
Q	900	1,800	1,4800	21,000
R	500	4,600	6,900	9,500

(a) State and explain the general trend in variation of ionization energies. (03 marks)

The successive ionization energies increase due to increase in effective nuclear charge on the remaining electron each time an electron is removed from an atom.

(b) State the group and period to which element P belongs. In each case give a reason for your answer

Group:

Group 3

Reason:

The big difference between the third and fourth ionization energies suggests that the first 3 electrons are in the outermost shell while the fourth electron is removed from inner stable electron shell.

Period:

No evidence

Reason:

None applicable

(c) The wavelength at the start of the continuum in the sodium emission spectrum is 242nm. Calculate the first ionization energy of sodium in KJmol $^{-1}$
(C = 3.0 x $10^8 ms^{-1}$, Planks' constant = 6.626 x 10^{-34} Js and Avogdro's constant (L) = 6.023 x 10^{23} mol^{-1}) (03 marks)

Energy = $h\frac{C}{\lambda}$ L ($Jmol^{-1}$) = 6.626 x 10^{-34} x $\frac{3.0 \times 10^8}{242 \ x \ 10^{-9}}$ x 6.023 x 10^{23} = 494.7$kJmol^{-1}$

16. A compound K is a colourless crystalline solid. When K was heated strongly it gave off brown fumes and a black residue. K dissolved in water to give a colourless solution.

The solution of K was divided into two portions.

(a) To the first portion was added a few drops of concentrated nitric acid followed by a little solid lead (IV) oxide and then boiled. A purple solution formed

(i) Identify the cation in the solution of K (01 marks)

Mn^{2+}

(ii) Write equation of reaction leading to the formation of the purple solution (1 ½ marks)

$2Mn^{2+}(aq) + 5PbO_2(s) + 4H^+ \rightarrow 2MnO_4^{2-}(aq) + 5Pb^{2+}(aq) + 2H_2O(l)$

(b) To the second portion was added sodium carbonate solution state what was observed and write equation of reaction that took place. (2 marks)

Observation

White precipitate.

Equation

$Mn^{2+}(aq) + CO_3^{2-}(aq) \rightarrow MnCO_3(s)$

(c) On further elemental analysis K was found to contain 19.1% of nitrogen and 43.6% oxygen.

(i) Determine the empirical formula of K. (02 marks)

Element	Mn	N	O
Percentages	37.3	19.1	43.6
Atomic mass	52	14	16
Moles	0.72	1.36	2.73
Mole ratio	1	2	4

Empirical formula MnN_2O_4

(ii) 10g of K dissolved in 1000g of water lowered the freezing point of solution by 0.127°C. Calculate the molecular formula of K.
(Kf for water is 1.86°C mol $^{-1}$ per 1000g) (2 ½ marks)

Formula mass = $\frac{10\ x\ 1.86}{0.127}$ = 146
Molecular formula
$(MnN_2O_4)n = 146$
n = 1
therefore molecular formula = MnN_2O_4

17. Name the reagents that can be used to distinguish between the following pairs of ions. In each case state what is observed when each member of the pair is separately treated with the reagent. (3 marks)

(a) CrO_4^{2-} and $Cr_2O_7^{2-}$

Reagent
HCl

Observation
CrO_4^{2-} color turns orange

$Cr_2O_7^{2-}$ color remains orange

(b) SO_3^{2-} and $S_2O_3^{2-}$

Reagent
HCl

Observation
SO_3^{2-} effervescence
$S_2O_3^{2-}$ yellow precipitate

(c) $\begin{matrix} COO^- \\ | \\ COO^- \end{matrix}$ and CH_3COO^-

Reagent
Acidified potassium manganate (VII)

Observation

(d) $\begin{matrix} COO^- \\ | \end{matrix}$
COO^- potassium manganate (VII) decolorizes
CH_3COO^- no observable change

End