Digital Teachers

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525/1

S6 CHEMISTRY

Exam 23

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

Answer all questions from this section.

1. (a) (i) The decay law is given the expression

$$-\frac{dN}{dt} = \lambda \mathrm{N}$$

State what the symbols represent. (01½)

λ rate constant
dt = change in tome
N amount of decaying substance available

(ii) Using the above expression derive the expression for the relation between half-life and the decay constant. (02)

Collecting like terms

$-\frac{dN}{N} = \lambda \mathrm{dt}$

Integrating both sides

$-\int \frac{dN}{N} = \lambda \int dt$

-InN = λt + C

t = 0, C - InN_0

Substituting for C and rearrangement

$In\frac{N_0}{N} = \lambda t$

When t = half-life $t_{\frac{1}{2}}$; N = $\frac{N_0}{2}$

In $\frac{N_0}{\frac{N_0}{2}} = \lambda t_{\frac{1}{2}}$

Half-life, $t_{\frac{1}{2}} = \frac{In2}{\lambda} = \frac{0.693}{\lambda}$

(b) (i) Nickel(^{63}Ni) decays to copper (^{63}Cu)

Name the particle emitted and write the equation for the reaction:

Name of particle; (01)

Beta particle

Equation

$^{63}_{28}Ni \rightarrow {}^{63}_{29}Cu + {}^{0}_{-1}\beta$

(ii) Calculate the time taken for $\frac{15}{16}$ of nickel to be change to copper.

[The half-life for nickel is 120 years] (02)

Rate constant, λ = $\frac{0.693}{120}$ yr^{-1}

Fraction of Ni undecayed = 1 - $\frac{15}{16}$ = $\frac{1}{16}$

From $In\frac{N_0}{N} = \lambda t$

In$\frac{1}{\frac{1}{16}}$ = $\frac{0.693}{120}$t

t =480years

2. (a) State conditions for the reaction between aluminium oxide and sulphuric acid and write the equation for the reaction.

Conditions;

Dilute acid

Equation

$Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3\ (aq) + 3H_2O(l)$

(b) The resultant solution in (a) was mixed with aqueous sodium carbonate solution. State what would be observed and write equation for the reaction that takes place

Observation; (02½)

Effervescence and white precipitate

Equation;

$2Al^{3+}(aq) + 3CO_3^{2-}(aq) + 3H_2O(l) \rightarrow 2Al(OH)_3(s) + 3CO_2(g)$

3. The following experimental results were obtained for the reaction

A + 2B $\longrightarrow$ products

Exp	Initial concentrations (mol l^{-1})		Initial rate (mol l^{-1} S^{-1})
	A	B	
1	3.0 x 10^{-2}	3.0 x 10^{-2}	2.7 x 10^{-5}
2	3.0 x 10^{-2}	6.0 x 10^{-2}	5.4 x 10^{-5}
3	6.0 x 10^{-2}	3.0 x 10^{-2}	10.8 x 10^{-5}

(a) (i) Deduce the order of reactions with respect to

A;

2

B;

1

(ii) Write the expression for the rate equation (0½)

Rate = $K[A]^2[B]$

(b) The rate of reaction under certain conditions for temperature and pressure is x. Express the rate in terms of x when the following changes are made. (0 ½ each)

(i) The concentration B is halved while the concentration of A remains unchanged

½ x

(ii) The rate constant is doubled, by increasing temperature, but keeping the concentrations of A and B unchanged.

2x

(iii) If 90% of B is removed by precipitation, without affecting concentration of A.

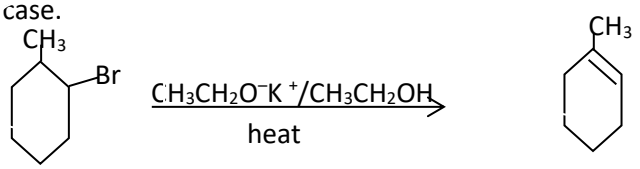
$0.01^2x = 0.0001x$

(c) Calculate the value of the rate constant and state its units. (02)

$2.7 \times 10^{-5} = K \times (3.0 \times 10^{-2})^2(3.0 \times 10^{-2})$

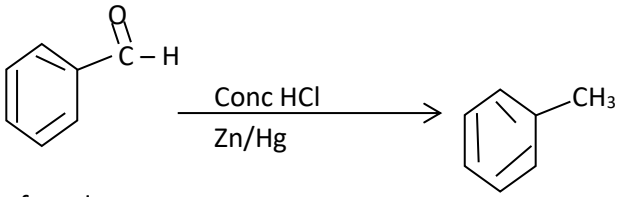
$K = 1 mol^{-2}l^2$

4. Complete the following reaction equations and write the IUPAC names of the main organic product in each case. (01½)

(a) 

Name of product;

1-methylcyclopropene

(b) 

Name of product;

Methylbenzene

(c) $(CH_3)_3COH \xrightarrow{\text{anhydrous } ZnCl_2/\text{Conc HCl}} (CH_3)_3C\text{-}Cl$

Name of product. 2-chloro-2-methylpropane

5. (a) Write half equation(s) to show the action of hydrogen peroxide as
(i) an oxidizing agent (01 mark each)

$H_2O_2 + 2H+ + 2e \rightarrow 2H_2O(l)$

(ii) a reducing agent

$H_2O_2 - 2e \rightarrow 2H^+(aq) + O_2(g)$

(b) State what is observed and in each case write equation of reaction that take place when hydrogen peroxide is added to the following mixtures; (01 ½ marks each)

(i) Acidified potassium chromate (VI) solution

Observation

Blue solution

Equation

$Cr_2O_7^{2-}(aq) + 4H_2O_2(l) + 2H+(aq) \rightarrow 2CrO(O_2)_2 + 5H_2O(l)$

(ii) Iron (II) sulphate in dilute sulphuric acid

Observation

Green solution turns brown

Equation

$H_2O_2\ (aq) + 2F^{2+}(aq) + 2H^+(aq) \rightarrow 2H_2O(l) + 2Fe^{3+}(aq)$

(c) Give one reason why hydrogen peroxide is not used in estimation of concentration of iron (II) ions in volumetric analysis (01)

Fe^{3+} catalyzes the decomposition of hydrogen peroxide

6. (a) Explain what is meant by the term first election affinity. (01)

First electron affinity is energy change when 1 mole of electrons is added to gaseous atoms to form gaseous ions with single negative charge.

(b) State three factors that can affect electron affinity. (01 ½)

- atomic radius

- electronegativity

- electropositivity

(c) The first electron affinities of some elements of period 3 are given in the table below

Element	Al	Si	P	S
First electron affinity ($kJmol^{-1}$)	– 44	– 134	– 71.7	– 200

(i) State the trend in variation of electron affinities (0 ½)

Generally electronegativity increases from Aluminium to sulphur

(ii) Explain your answer in c (i) above (02)

Electron affinity increases from Al to S due to increase in electronegativity. P has abnormally low electron affinity because it has stable electron configuration that oppose addition of electrons

7. (a) The enthalpies of some reactions are given below

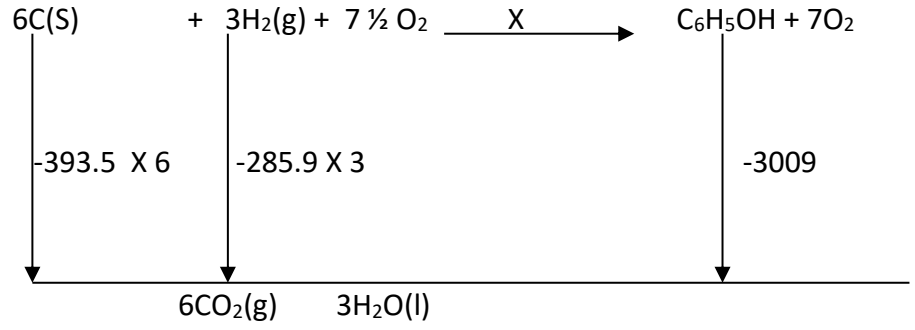
$\Delta H^{\theta}/kJmol^{-1}$

(i) $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$ ΔH^{θ}_1 = −393.5

(ii) $H_2(g) + ½\ O_2(g) \longrightarrow H_2O(l)$ ΔH^{θ}_2 = −285.9

(iii) $C_6H_5OH(s) + 7O_2(g) \longrightarrow 6CO_2(g), +3H_2O\ (l)$ ΔH^{θ}_3 = -3009

Calculate the standard enthalpy of formation of phenol from its elements. (03)



X -3009 = -393.5 X 6 – 285.9 X 3

X = 209.7$kJmol^{-1}$

(b) (i) From your answer in (a) state whether phenol is a stable compound or not. (0 ½)

It is stable

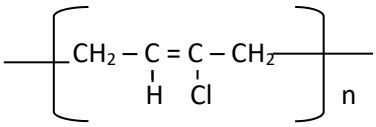
(ii) Give a reason for your answer in b (i) above (01 mark)

Its formation involves loss of energy

(d) Write equation'(s) to show how phenol can be synthesized from chlorobenzene. (01 ½ mark)

$C_6H_5Cl \xrightarrow{NaOH,\ heat} C_6H_5O^- \xrightarrow{H^+} C_6H_5OH$

8. (a) Neoprene is a synthetic polymer which has the following structure



(i) Name the type of polymerization reaction which leads to formation of neoprene

Addition polymerization

(ii) Write the structure and name of monomer of neoprene. (01)

$CH_2 = CH - C(Cl) = CH_2$ 2-chlorobut-2,3-diene

(b) When 350g of the monomer was polymerized 9.89×10^{-2} moles of neoprene was formed. Calculate the relative molecular mass of neoprene. (2)

Formula mass of neoprene = $350/9.89 \times 10^{-2} = 3540$

(c) State one use of neoprene (0½)

Containers

SECTION B

Attempt only six questions in this section

10. (a) Explain what is meant by the term common ion effect. (01)

This is the reduction in solubility of ionic salt in a solution that contain a common ion

(b) Silver chromate is sparingly soluble in water.
Write

(i) Equation for solubility of silver chromate in water (1 ½)

Ag_2CrO_4 (aq) $\leftrightarrow$ $2Ag^+$(aq) + CrO_4^{2-}(aq)

(ii) The expression for solubility product, Ksp for silver chromate. (0 ½)

Ksp = $[Ag^+]^2[CrO_4^{2-}]$

(c) A saturated solution of silver chromate contains 2.4 x 10^{-2}g per liter at 20^{o}C

Calculate the value for the solubility product Ksp for silver chromate at 20^{o}C. (02)

Formula mass of Ag_2CrO_4 = 108 x 2 + 52 + 16 x 4 = 332

Molarity of silver chromate = $\frac{2.4\ x\ 10^{-2}}{332}$= 7.2 x 10^{-5}moldm^{-3}

$[Ag^+]$ = 7.2 x 10^{-5} x 2 = 1.4 x10^{-4}moldm^{-3}

[CrO42-] = 7.2 x 10^{-5}moldm^{-3}

Ksp = $(1.4 \times 10^{-4})^2(7.2 \times 10^{-5})$ = 1.41 x10^{-12}mol^{3}dm^{-9}

(d) Chloride ions in solution can be determined by titration with silver nitrate in the presence of chromate ions. The end point is indicated by a red precipitate of silver chromate.

(i) Explain why silver chromate does not precipitate until the end point is reached. (01)

Sliver chromate is more soluble than silver chloride

(ii) Calculate the solubility of silver chloride in g/dm^{-3} of 0.1M KCl. (3marks)

[Solubility product for silver chloride is 1.6 x 10^{-10} mol^2 l^{-2}]

Solution

Let solubility in mole per liter be x

$[Ag^+]$ = x

$[Cl^-] = 0.1 + x \approx 0.1$ because x is very small

⇨ $0.1x = 1.6 \times 10^{-10}$

$x = 1.6 \times 10^{-9} moldm^{-3}$

Formula mass of AgCl = 108 + 35.4 = 143.5

Concentration of AgCl in gdm^{-3} = 143.5 x 1.6 x 10^{-9} = 2.3 x $10^{-7} gdm^{-3}$

11. (a) A compound Y contains carbon, hydrogen and nitrogen. On combustion, 0.72g of Y produced 1.615g of carbon dioxide and 0.42g produced $84cm^3$ of nitrogen at 15°C and 760mmHg. Calculate the empirical formula of Y. (04 ½)

Mass of carbon in 1.615g of CO_2 = $\frac{1\ x\ 1.615}{44}$ = 0.44g

Volume of nitrogen produced by 0.72g of Y at 15^0C and 760mmHg = $\frac{0.72\ x\ 84}{0.42}$ = $144cm^3$

Volume of nitrogen at stp

$\frac{760V}{273} = \frac{144\ x\ 760}{(273+15)}$

$V = \frac{144\ x\ 273}{288} = 136.5cm^3$

Mass of nitrogen in $136.5cm^3$

$22400cm^3$ contain 28

$136.5cm^3$ contain $\frac{136.5\ x\ 28}{22400}$ = 0.17g

Mass of hydrogen = 0.72 – (0.44 + 0.17) = 0.11g

Elements	C	H	N
Mass	0.44	0.11	0.17
RAM	12	1	14
Moles	0.037	0.11	0.012
Mole ratio	3	9	1
Empirical formula	C_3H_9N		

(b) When Y was vaporized, it took 38 seconds to diffuse through the same porous partition under similar conditions whereas oxygen takes 28 seconds. Calculate the molecular formula of Y (03)

$$\frac{Rate\ of\ Y}{Rate\ of\ oxygen} = \sqrt{RFm\ of\ O_2 / RFM\ of\ Y}$$

$$\frac{\frac{V}{38}}{\frac{V}{28}} = \sqrt{\frac{32}{RFM\ of\ Y}}$$

Y = 59

$(C_3H_9N)n = 59$

n = 1

therefore molecular formula of Y = C_3H_9N

(c) Y reacts with a mixture of concentrated hydrochloric acid and aqueous sodium nitrite to form a yellow oily liquid.

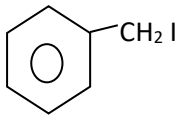
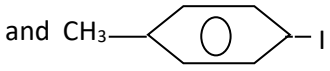
(i) Identify Y (0 ½)

Ethylmethylamine; $CH_3CH_2NHCH_3$

(ii) Write equation of reaction that takes place. (01 mark)

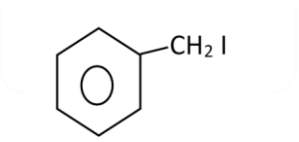
$CH_3CH_2NHCH_3 + NaNO_2 + HCl \rightarrow CH_3CH_2N(CH_3)\text{-}NO + NaCl + H_2O$

12. Name the reagents that can be used to distinguish between the following pairs of compounds. In each case state what would be observed if each member of the pair is separately treated with the reagent. (03 marks each)

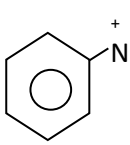
(a)  and 

Name of reagent (s): hot sodium hydroxide followed by lead iodide

Observation(s)

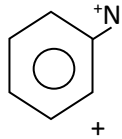
 

Yellow precipitate no observable change

(b)  and $CH_3CH_2\overset{+}{N}\equiv NCl^-$

Name of reagent: phenol

Observation(s)

 orange solution

$CH_3CH_2\overset{+}{N}\equiv NCl^-$ no observable change

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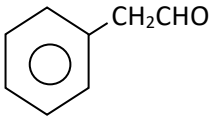
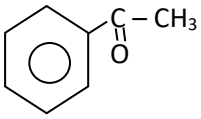
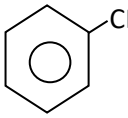
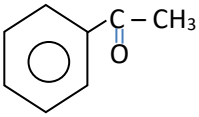
(c)  and 

	Observation	
Name of reagent;		
Fehling's solution	Red ppt	No observable change
Ammoniacal silver nitrate	Silver mirror	No observable change
Iodine in sodium hydroxide solution	No observable change	Yellow ppt

13. (a) (i) Compare the reactivity of hydrides of group (VII) elements with concentrated sulphuric acid.
(Write equation(s) for the reaction(s) which take place if any) (04)

HF and HCl do not react

HBr and HI are oxidized to element

$2HX (X = Br \text{ or } I) + SO_4^{2-}(aq) + 2H^+(aq) \rightarrow X_2 + SO_2(g) + 2H_2O(l)$

(ii) Give a reason for the difference in reactivity shown by the hydrides in a(i) above. (01)

Br^- and I^- are strong reducing agents while F^- and Cl^- are not

(b) The bond lengths of the hydrides of group (VII) elements are given in the table below

Hydride	HF	HCl	HBr	HI
Bond length (A^o)	0.86	1.28	1.42	1.60

(i) State the trend in variation of bond length of the hydrides. (01)
H-X bond length increases from HF to HI

(ii) Explain your answer in b (i) above. (03)

Electronegativity decreases from F to I reducing electron attraction between H and X

14. (a) Nitrogen reacts with hydrogen in a mole ratio of 1:3 to form ammonia.
Write;
(i) Equation for the reaction that takes place. (01½)

N_2 (g) + $3H_2$(g) ⟷ $2NH_3$(g)

(ii) the expression for the equilibrium constant (Kc) (0 ½)

Kc = $\frac{[NH_3]^2}{[N_2][H_2]^3}$

(b) State the conditions used to obtain maximum yield of ammonia during it manufacture by the Habers process. (01½)

Temperature: 400-500^0

Pressure: 200 atmosphere

Catalyst: iron

(c) The percentage of ammonia in the equilibrium mixture of gases was found to be 15% at 600^{o}C. Calculate the equilibrium constant (Kc) for the reaction at 600^{o}C. (04)

Percentage of H_2 and N_2 = 100 – 15 = 85

Percentage of H_2 = $\frac{3}{4}$ x 85 = 63.75

Percentage of N_2 = $\frac{1}{4}$ x 85 =21.25

Kc = $\frac{15^2}{21.25\ x\ 63.75^3}$ = 4 x 10^{-5}mol-1dm^6

(d) State what would happen to the equilibrium position of the reaction in a(i) above when hydrogen chloride gas is added to the equilibrium mixture. Give a reason for your answer. (01½)

Equilibrium shift to right to replace ammonia removed by HCl

15. Write equations to show how the following conversions can be effected. (03 marks each)
(a) Ethanol to benzene

CH_3CH_2OH —Conc. H_2SO_4, heat→ $CH_2=CH_2$ —Br_2/CCl_4→ $CH_2(Br)-CH_2(Br)$ —EtOH/EtO-, heat→

$HC\equiv CH$ —Fe tube→ 

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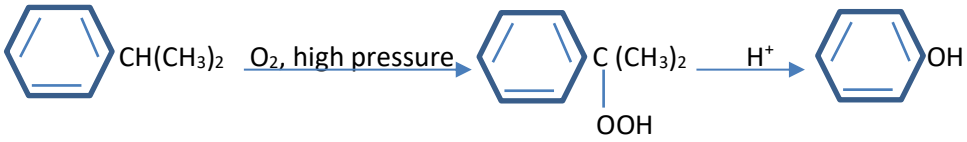
(b) 1, 2 – dibromo ethane to ethanol .

$CH_2(Br) - CH_2(Br)$ —EtOH/EtO-, reflux→ $HC \equiv CH$ —lindlar catalyst→ $CH_2 = CH_2$ —dil H_2SO_4, warm→ CH_3CH_2OH

(c) 2-Phenyl propane to phenol.



16. (a) (i) State three characteristic properties exhibited by cobalt as a transition element. (01 ½)

Forms colored cations, e.g. Co^{2+} is pink

Has variable oxidation states i.e. +2 and +3

Forms complexes

(ii) Explain why zinc is not considered to be a transition element. (02)

It ions has full d-orbital

Forms colorless compound

(b) Cobalt (II) nitrate decomposes on heating in the absence of air forming are green solid and dissolves in water forming a pink solution.

(i) Write equation for decomposition of cobalt (II) nitrate. (01 ½)

$2Co(NO_3)_2(s) \xrightarrow{heat} 2CoO(s) + 4NO_2(g) + O_2$

(ii) Name the species responsible for the pink color of solution. (01)

$Co(H_2O)_6^{2+}$

(c) To the aqueous solution in (b) was added concentrated hydrochloric acid dropwise until in excess. State what is observed and write equation for the reaction that takes place. (03)

(i) Observation

Solution turns blue

(ii) Equation;

$Co(H_2O)_6^{2+} + 4Cl^-(aq) \rightarrow CoCl_4^{2-}(aq)$

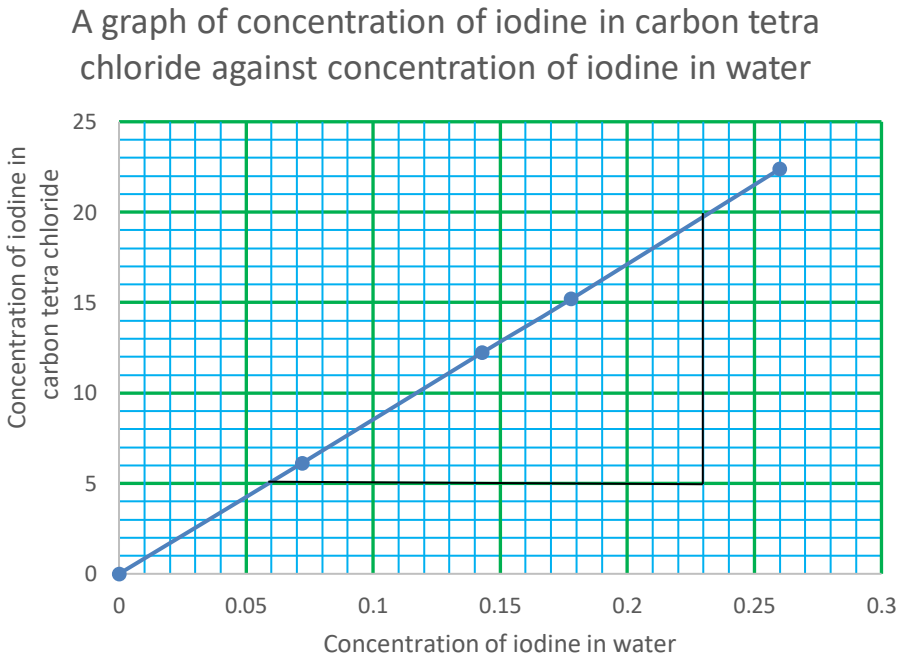
17. (a) Explain what is meant by the term partition coefficient. (02)

Partition coefficient is a ration of solute concentration in two immiscible liquids at equilibrium

(b) The table below shows the concentrations of iodine in the two layers when shaken with a mixture of carbon tetrachloride and water at 25°C.

Concentration of I_2 in CCl_4/moldm $^{-3}$	6.12	12.24	15.20	22.38
Concentration of I_2 in water/ moldm $^{-3}$	0.072	0.143	0.178	0.260

(i) Plot a graph of concentration of iodine in carbon tetra chloride against concentration of iodine in water



(ii) From the graph determine the partition coefficient for iodine distributed between carbon tetra chloride and water. (02)

$$K_D = \frac{20 - 5}{0.23 - 0.06} = 88.2$$

(c) State two applications of the partition coefficient. (02)

Solvent extraction

Study of complexes

END