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525/1

S6 CHEMISTRY

Exam 14

PAPER 1

DURATION: 2 HOUR 45 MINUTES

For Marking guide contact and consultations: Dr. Bbosa Science 0778 633 682,

This paper, 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.

Where necessary use the following:

Molar gas constant, R = $8.31 \text{ JK}^{-1} \text{ mol}^{-1}$

Molar volume of a gas at s.t.p = 22.4 litres

Standard temperature = 273K

Standard pressure = 10125 Nm^{-2}

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 questions from this section

1. (a)(i) The decay law is give in the expression below

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

State what the symbols represent.

(1 ½ marks)

N is in number of nuclei that undergo decay in time (t)

λ = decay constant or the probability of decay per unit time

- (ii) Using the above expression derive the expression for relating the half-life ($t_{1/2}$) and a decay constant. (2marks)

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

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

Integrating both sides

$$-\ln N = \lambda t + C$$

$$t = 0$$

$$C = -\ln N_0 \text{ where } N_0 \text{ is the initial number of disintegrating nuclei}$$

Then

$$\ln N_0 - \ln N = \lambda t$$

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

$$t = \text{half life } t_{1/2}, N = \frac{1}{2} N_0$$

$$t_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

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

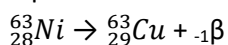
Name the particle emitted and write the equation for the reaction:

Name of the particle

(1mark)

Beta particle

Equation:



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

(the half-life of nickel is 120 years)

(2marks)

$$\lambda = \frac{0.693}{120} \text{ per year}$$

$$N = 1 - \frac{15}{16} = \frac{1}{16}$$

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

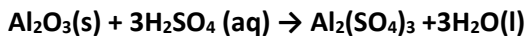
$$t = 480 \text{ years}$$

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

Conditions

heat

Equation



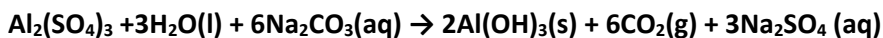
(b) The resultant solution in (a) was mixed with aqueous sodium carbonate solution. State what was observed and write equation for the reaction that took place.

Observation

(2 ½ mark)

White precipitate and effervescence.

Equation



3. The following experimental results were obtained for the reaction



Experiment number	Initial concentration (mol l ⁻¹)		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) Deduce the order of reaction with respect to

(i) A

2 because doubling the concentration A quadruples the rate

(ii) B

1 because doubling the concentration of B double the rate

(iii) Write the expression for the rate equation (½ mark)

$$\text{Rate} = K[A]^2[B]$$

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

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

$$\frac{1}{2}x$$

(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 the concentration of A
The rate is multiplied by $(0.1)^2$ or 0.01

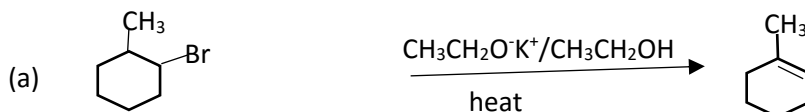
(c) Calculate the value of the rate constant and state its units (2marks)

Using experiment 1

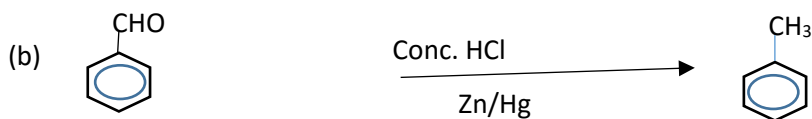
$$2.7 \times 10^{-5} = K(3.0)^2(3.0)$$

$$K = 10^{-6} \text{ mol}^{-2} \text{ l}^2 \text{ s}^{-1}$$

4. Complete the following reaction equations and write the IUPAC names of the main organic product in each case. (1 ½ mark each)

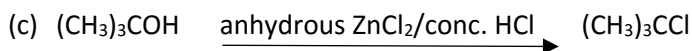


Name of the product: 1-methylcyclohexene



Name of the product

Methylbenzene



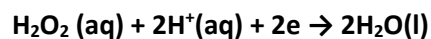
Name of the product

2-chloropropane

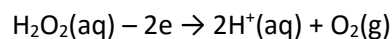
5. (a) Write half equation (s) to show the action of hydrogen peroxide as

(i) Oxidizing agent

(1mark)



(ii) Reducing agent.



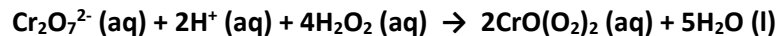
(b) State what is observed and in each case write equation of the reaction that takes place when hydrogen peroxide is added to the following mixtures: (1½ mark each)

(i) Acidified potassium chromate (VI) solution)

Observations

Purple solution

Equation

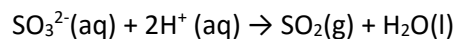


(ii) Iron (II) sulphite in dilute sulphuric acid

Observations

a colorless gas having the suffocating smell of burning Sulphur given off

Equation



- (c) Give one reason why hydrogen peroxide is not used to estimate the concentration of iron (II) ions in volumetric analysis. (1mark)

Because iron (III) catalyzes decomposition of hydrogen peroxide

6. (a) Explain what is meant by the term first electron affinity? (1mark)

Electron affinity is energy change when 1 mole of electrons are added to gaseous atoms of anions to form gaseous anions.

- (b) State three factors that can affect electron affinity. (1 ½ mark)

- **electronegativity**
- **Atomic size**
- **Nuclear charge**

- (d) The first electron affinities of some of period 3 elements in the periodic table are shown below

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

- (i) State the trend in the variation of electron affinities. (½ mark)

Generally first electron affinity increases across the period from Al to S. The first electron affinity of phosphorus is abnormally low.

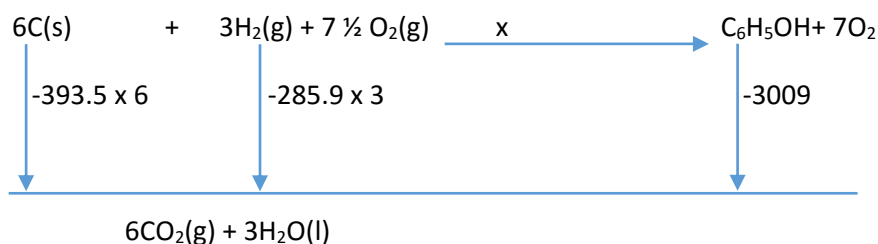
- (ii) Explain your answer in c(i) above (2marks)

The first electron affinity generally increase from Al to S due to increase in electronegativity. The first electron affinity of P is abnormally low because it has relatively stable electron configuration that resist addition of electron.

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

- (i) $\text{C}(\text{s}) + \text{O}_2(\text{g}) \longrightarrow \text{CO}_2(\text{g})$ $\Delta H_1^0 = -393.5 \text{ kJmol}^{-1}$
- (ii) $\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \longrightarrow \text{H}_2\text{O}(\text{l})$ $\Delta H_2^0 = -285.9 \text{ kJmol}^{-1}$
- (iii) $\text{C}_6\text{H}_5\text{OH}(\text{s}) + 7 \text{O}_2(\text{g}) \longrightarrow 6\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$ $\Delta H_3^0 = -3009 \text{ kJmol}^{-1}$

Calculate the standard enthalpy of formation of phenol from its elements (3marks)



$$-393.5 \times 6 - 285.9 \times 3 = x - 3009$$

$$x = -209.7 \text{ kJ mol}^{-1}$$

Therefore, enthalpy of formation of phenol = $-209.7 \text{ kJ mol}^{-1}$

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

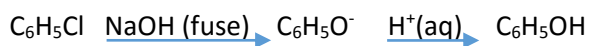
It is stable

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

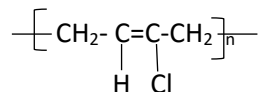
(01mark)

because enthalpy of formation is negative

(c) Write equation (s) to show how phenol can be synthesized from chlorobenzene. (1½ mark)



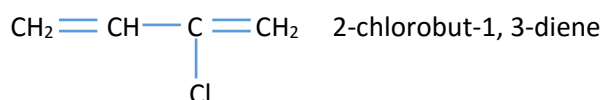
8. (a) Neoprene is a synthetic polymer which has the following structure.



(i) Name the type of polymerization reaction which leads to formation of neoprene. (½ marks)

Addition polymerization

(ii) Write the structure and name the monomer the neoprene. (1marks)



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

$$\text{Molar mass} = \frac{350}{9.89 \times 10^{-2}} = 3540$$

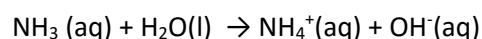
(c) State one use neoprene (½ mark)

Neoprene exhibits good chemical stability and maintains flexibility over a wide temperature range.

it is used in a wide variety of applications, such as laptop sleeves, orthopedic braces (wrist, knee, etc.), electrical insulation, liquid and sheet applied elastomeric membranes or flashings, and automotive fan belts.

9. Calculate the pH of 0.1 mol dm^{-3} solution of ammonia.

(Base dissociation constant, K_b , at 25°C for ammonia = $1.8 \times 10^{-5} \text{ mol dm}^{-3}$) (3marks)



Initially	0.1	-	-
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At equilibrium	$(0.1 - x)$	x	x
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$$\frac{x^2}{0.1} = 1.8 \times 10^{-5}$$

$$[\text{OH}^-] = 1.34 \times 10^{-3} \text{ mol dm}^{-3}$$

$$[\text{H}^+] = \frac{10^{-14}}{1.34 \times 10^{-3}} = 7.46 \times 10^{-12} \text{ mol dm}^{-3}$$

$$\text{pH} = -\log 7.46 \times 10^{-12} = 11.1$$

SECTION A

(Attempt only questions in this section)

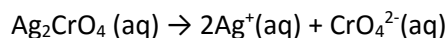
10 (a) Explain what is meant by the term common ion effect. (1mark)

The common-ion effect refers to the decrease in solubility of sparingly soluble ionic compound by the addition to the solution of a soluble compound with an ion in common with the compound.

(b) Silver chromate is sparingly soluble in water

Write

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



(ii) The expression for the solubility product, K_{sp} , for silver chromate. (½ mark)

$$K_{sp} = [\text{Ag}^+]^2[\text{CrO}_4^{2-}]$$

(c) A saturated solution of silver chromate contains 2.4×10^{-2} g per liter at 20°C . Calculate the value for the solubility product, K_{sp} , for silver chromate at 20°C .

$$\text{Formula mass of Ag}_2\text{CrO}_4 = (108 \times 2 + 52 + 16 \times 4) = 332$$

$$\text{Concentration of Ag}_2\text{CrO}_4 = \frac{2.4 \times 10^{-2}}{332} = 7.2 \times 10^{-5} \text{ mol dm}^{-3}$$

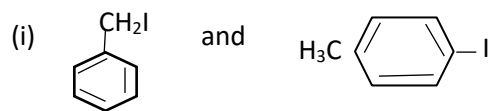
$$K_{sp} = [2 \times 7.2 \times 10^{-5}]^2 [7.2 \times 10^{-5}] = 1.5 \times 10^{-9} \text{ mol}^3 \text{ dm}^{-9}$$

(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 (01marks)

The solubility of potassium chromate is higher than the solubility of silver chloride

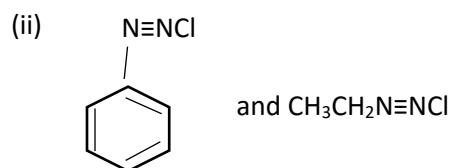
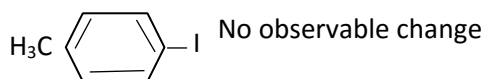
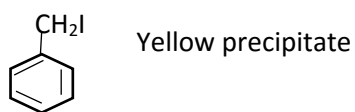
12. Name the reagents that can be used to distinguish between the following pairs of compounds. In each case state what would be observed if each member of the pair is separately treated with the reagent. (03marks)



Name of reagent(s)

Hot sodium hydroxide followed by acidified lead (II) nitrate

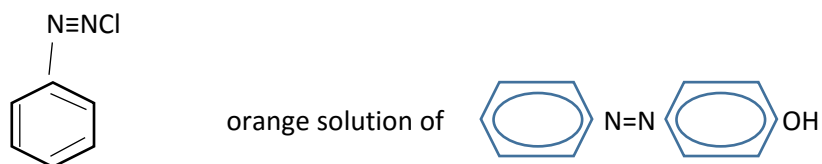
Observations



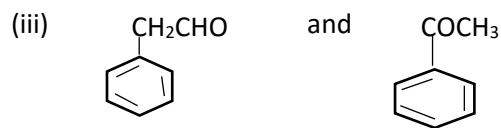
Name of reagent(s)

Phenol

Observations

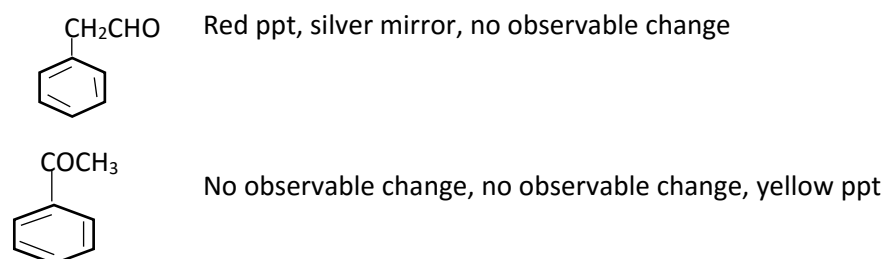


$\text{CH}_3\text{CH}_2\text{N}\equiv\text{NCl}$ no observable change



Name of reagent(s) Fehling's solution, ammoniacal silver nitrate, iodine in sodium hydroxide solution

Observations



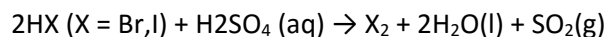
13 (a)(i) Compare the reactivity of hydrides of group (VII) elements with concentrated sulphuric acid.

(write equation (s) for the reaction(s) which takes place if any)

(04marks)

HF and HCl do not react

HBr and HI are oxidized to bromine and iodine respectively



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

(1mark)

Br⁻ and I⁻ are strong reducing agents

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

Hydride	HF	HCl	HBr	HI
Bond length (Å)	0.86	1.28	1.42	1.60

(i) State the trend in the variation of bond length of the hydrides. (1mark)

The H-X bond length increase from HF to HCl to HBr to HI

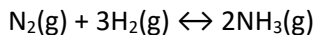
(ii) Explain your answer in (b)(i) above (3marks)

Due to increase in the size of halogen atom and reduction in electronegativity of halogen atoms

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. (1 ½ mark)



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

$$K_c = \frac{[\text{NH}_3]^2}{[\text{N}_2][\text{H}_2]^3} \text{mol}^{-2}\text{dm}^6$$

(b) State the conditions used to obtain maximum yield of ammonia during its manufacture by the Haber process.

Temperature: 400-450°C

Pressure: 200atmosphere

Catalyst pure iron containing KOH as a promoter

(c) the percentage of ammonia in equilibrium mixture of gases was found to be 15% at 600°C.

Calculate the equilibrium constant (K_c) for the reaction at 600°C. (4marks)

Percentage of ammonia = 15

Percentage of hydrogen + percentage of nitrogen = 100 - 15 = 85

Percentage of hydrogen = $\frac{2}{3} \times 85 = 56.7\%$

Percentage of nitrogen = $\frac{1}{3} \times 85 = 28.3\%$

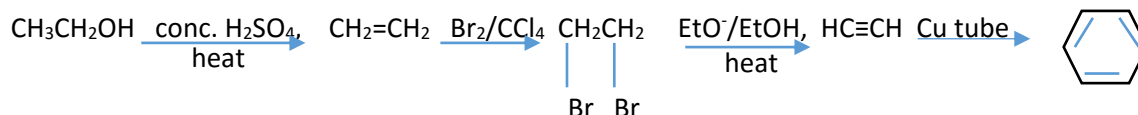
$$K_c = \frac{0.15^2}{0.567^3 \times 0.283^1} = 0.44 \text{ mol}^{-2}\text{dm}^6$$

(d) State what would happen to 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. (1 ½ mark)

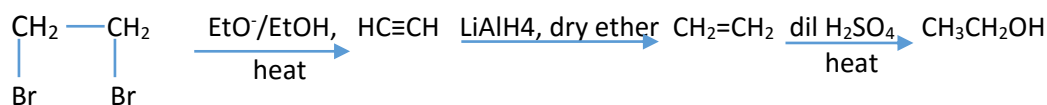
Equilibrium shifts to the right to replace ammonia that reacts with HCl to produce ammonium chloride

15. Write equation to show how the following conversions can be effected. (3marks each)

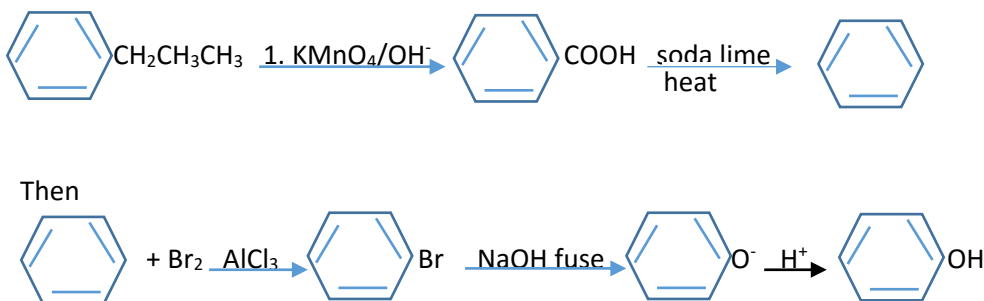
(a) Ethanol to benzene



(b) 1,2-dibromoethane to ethanol



(c) Phenylpropane to phenol



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

- Variable oxidation states i.e. +2, +3
- Colored compound, Co^{2+} is pink
- Forms complexes e.g. CoCl_4^{2-}

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

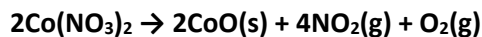
(2marks)

- has full d-orbital
- forms white compounds

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

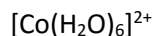
(i) Write equation for the decomposition of cobalt (II) nitrate.

(1 ½ marks)



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

(1mark)

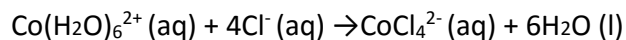


(c) to the aqueous solution in (b) was added concentrated hydrochloric acid dropwise until in excess. State what was observed and write equation for the reaction that took place.

(i) observation

Deep blue solution

equation



17. (a) Explain is meant by partition coefficient.

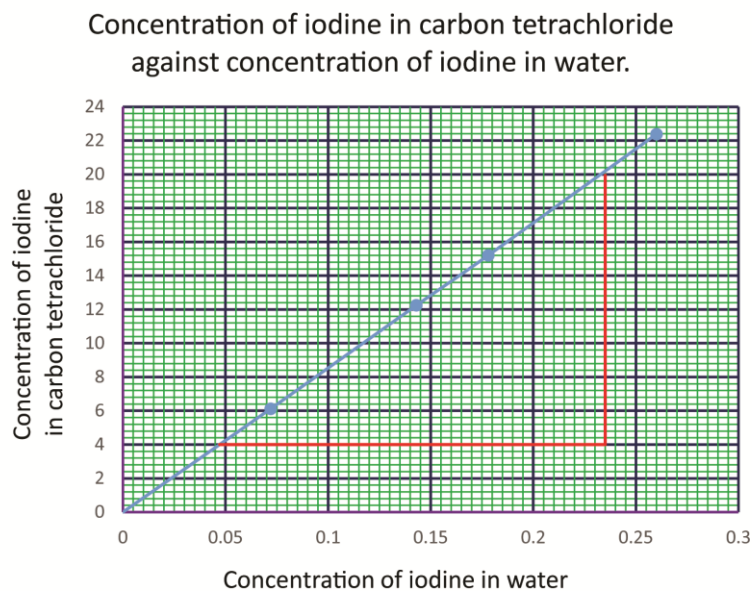
(2marks)

A partition coefficient (*P*) or distribution coefficient (*D*) is the ratio of concentrations of a compound in a mixture of two immiscible solvents at equilibrium

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

Concentration of I ₂ in CCl ₄ /mol dm ⁻³	6.12	12.24	15.20	22.38
Concentration of I ₂ in water /mol dm ⁻³	0.072	0.143	0.178	0.260

(i) Plot a graph of concentration of iodine in carbon tetrachloride against concentration of iodine in water. (03marks)



(ii) from the graph determine the partition coefficient for iodine distributed between carbon tetrachloride and water. (02 mark)

$$K_D = \text{slope of the graph} = \frac{20-4}{0.24-0.05} = 84$$

(c) State two applications of partition coefficient (2marks)

- solvent extraction
- Study of complexes

END