MAKERERE UNIVERSITY

00240579

EXAMINATION ANSWER BOOK

2017/2018 ACADEMIC YEAR SEMESTER ONE

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VERY IMPORTANT

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INSTRUCTIONS CONTINUE ON THE NEXT PAGE

Chemistry PP1

SECTION A (46 marks)

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Question _____

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1(a) Define partition coefficient (1 mark)

This is the constant ratio of the concentration of a solute in one immiscible solvent to its concentration in another immiscible solvent when the two immiscible solvents are in contact at equilibrium at constant temperature. (1½)

(b) At 25°C an aqueous solution of iodine containing 0.0516 g litre^{-1} is in equilibrium with a carbon tetrachloride solution containing 4.412 g litre^{-1} of iodine. The solubility of iodine in water is 0.34 g litre^{-1} calculate the solubility of iodine in carbon tetrachloride. (2½ marks)

$[I_2]$ in water = 0.0516 g l^{-1}

$[I_2]$ in CCl_4 = 4.412 g l^{-1}

$$K_D = \frac{[I_2]_{CCl_4}}{[I_2]_{H_2O}}$$

$$= \frac{4.412}{0.0516} = 85.5$$

(02½)

$$K_D = \frac{\text{solubility of iodine in } CCl_4}{\text{solubility of iodine in water}}$$

$$85.5 = \frac{\text{solubility of iodine in } CCl_4}{0.34}$$

$$\text{Solubility} = (0.34 \times 85.5) = 29.07 \text{ g l}^{-1}.$$

(04½)

(c) State three limitations of the distribution law. (1½ marks)

- Temperature must be kept constant
- The solute must be in the same molecular state in the two solvents (1½)
- Equilibrium has to be established
- The concentration of the solute in either solvents is low
- The two solvents must be immiscible with each other

(06)

05

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Question

2 (a) State what is observed and write equations for the reaction that occurs when

(a) a mixture of hydrochloric acid and sodium nitrite is reacted added to diethylamine. (1½ marks)

Observation:

Yellow oil ✓+

Equation: (0½)

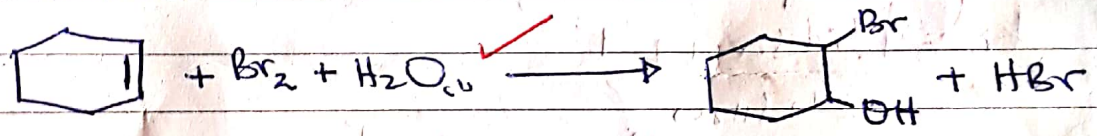
$CH_3CH_2NHCH_2CH_3 + HNO_2 \longrightarrow CH_3CH_2\underset{\displaystyle CH_2CH_3}{\overset{|}{N}}-N=O + H_2O$ ✓

(b) Cyclohexene is reacted with bromine water. (1½ marks)

Observation

The reddish brown solution turns colorless. ✓+ (0½)

Equation



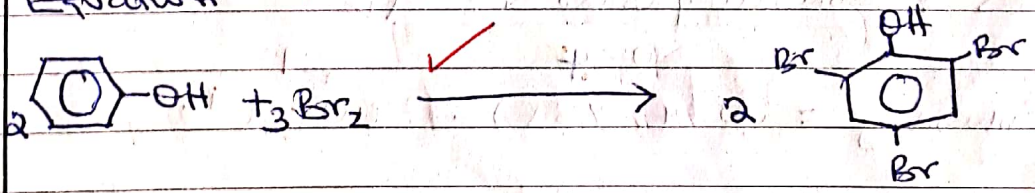
✓

(c) Hydroxybenzene is reacted with bromine: (1½ marks)

Observation:

White precipitate ✓+ (0½)

Equation



✓

4½ 5½

3 (a) Write balanced nuclear equations for the following reactions.

(i) loss of an alpha particle by Thorium-230 (1 mark)

$^{230}_{90}Th \longrightarrow {}^{4}_{2}He + {}^{226}_{88}Ra$ ✓ (1)

(ii) Fusion of a Nitrogen 15 and a proton to form another nucleus and an alpha particle. (1 mark).

$^{15}_{7}N + {}^{1}_{1}P \longrightarrow {}^{4}_{2}He + {}^{12}_{6}C$ ✓ (1)

(b)(i) Define decay constant (1 mark)

This is the proportion of atoms of an isotope decaying per unit time. ✓ (1)

(ii) Calculate the mass of radium-226 if 1g of it emits 3.7×10^{10} alpha particles per second. (3 marks)

$\frac{dN}{dt} = \lambda N$ ✓ $= 3.7 \times 10^{10}$ per second.

but Number of atoms of radium present in 1g sample

$= \left(\frac{6.02 \times 10^{23}}{226}\right) = 2.664 \times 10^{21}$ ✓

$\lambda = \frac{3.7 \times 10^{10}}{2.664 \times 10^{21}}$ ✓ $= 1.389 \times 10^{-11}$ per second. (03)

$t_{1/2} = \frac{\ln 2}{\lambda}$ ✓ $= \frac{0.693}{1.389 \times 10^{-11}}$ ✓ $= 4.99 \times 10^{10}$ ✓ seconds.

or 1582.36 years.

06

4(a) To an aqueous solution of copper (II) sulphate was added concentrated hydrochloric acid solution dropwise until in excess.

(i) State what was observed. (1 mark)

Blue solution turned yellow ✓ (1)

(ii) Write the equation of reaction that took place (1½ marks)

$Cu(H_2O)_6^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons CuCl_4^{2-}(aq) + 6H_2O(l)$ ✓ (1½)

(b) Explain your observation in a(i) (02 marks).

The blue solution is due to the presence of hexaaqua copper (II) ions in solution, ~~concentrated hydrochloric~~ When concentrated hydrochloric acid is added, a high concentration of chloride ions is introduced into the solution, these chloride ions replace the water ligand in the complex resulting into formation of tetrachloro cuprate (II) ions which make the solution yellow. (02)

04½

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Question

5(a) Carbon is in group (IV) of the periodic table but differs considerably from other elements in the group.

(a) State four properties in which carbon differs from other elements in the group. (2 mark)

- Carbon forms stable multiple bonds with itself and with other non metals while others don't. (02)
- Carbon forms gaseous oxides while others form solid oxide
- Carbon exhibits catenation while others don't.
- Carbon atom has inert pair effect while others don't
- Carbon forms compounds that are relatively inert while others form compounds that are reactive.

(b) Give one reason for the above anomalous behaviour of carbon. (½ mark)

- Carbon atom has a small atomic radius (½)
- Carbon lacks empty 2d-orbitals
- Carbon has a high electronegativity compared to other ...

(c) Write equation of reaction between carbon and

(i) Hot concentrated sulphuric acid (1½ mark)

$$C_{(s)} + 2H_2SO_{4(l)} \longrightarrow CO_{2(g)} + 2H_2O_{(l)} + 2SO_{2(g)}$$

(ii) steam (1½ mark) (03)

$$C_{(s)} + H_2O_{(g)} \longrightarrow CO_{(g)} + H_{2(g)}$$

6 Write equations to show how the following compounds can be synthesised. (05½)

(a) Ethanol to Butan-2-ol. (3½ mark)

$$CH_3CH_2OH \xrightarrow[360^\circ C]{Al_2O_3} CH_2 = CH_2$$

$$H_2C = CH_2 \xrightarrow{Br_2 / CCl_4} BrCH_2CH_2Br$$

$$BrCH_2CH_2Br \xrightarrow[heat]{\text{Alcoholic } KOH} HC \equiv CH$$

$$HC \equiv CH \xrightarrow{Na / \text{liquid } NH_3} HC \equiv CNa$$

$$HC \equiv CNa \xrightarrow{CH_3CH_2Br} HC \equiv C CH_2 CH_3$$

$CH_3CH_2C\equiv CH \xrightarrow[Hg^{2+},\ 60^oC]{H^+/H_2O} CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3$ ✓ ✓

(3½)

$CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3 \xrightarrow[\text{dry ether}]{LiAlH_4} CH_3CH_2\underset{OH}{CH}CH_3$ ✓ ✓

or $CH_3CH_2OH \xrightarrow{PCl_5} CH_3CH_2Cl$

$CH_3CH_2Cl \xrightarrow[\text{dry ether}]{Mg} CH_3CH_2MgCl \xrightarrow[\text{dry ether}]{CH_3CH_2CN} CH_3CH_2\overset{NMgCl}{\overset{\|}{C}}CH_3$

$CH_3CH_2MgCl \xrightarrow[\text{dry ether}]{CH_3\overset{O}{\overset{\|}{C}}H} CH_3CH_2\underset{OMgCl}{CH}CH_3$

$CH_3CH_2\underset{OH}{CH}CH_3 \xleftarrow[\text{dry ether}]{LiAlH_4} CH_3CH_2\overset{O}{\overset{\|}{C}}CH_3$ ✓ ✓

(b) Ethane from methanol. ✓ ✓ (1½ marks)

$CH_3OH \xrightarrow{PCl_5} CH_3Cl \xrightarrow{Na/\text{dry ether}} CH_3CH_3$ (01½)

05

7 Name reagents that can be used to distinguish between the following pairs of ions. State what would be observed if each compound is treated with the reagents you have named.

(a) Ba^{2+} (aq) and Mg^{2+} (aq) (3 marks)

Reagent:

Dilute sulphuric acid ✓

Observation.

Ba^{2+} – White precipitate. ✓ ✓ (03)

Mg^{2+} – No observable change.

(b) CH_3COO^- and $^-O-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-O^-$ (3 marks)

Reagent:

Acidified potassium manganate (VII) solution and Heat. ✓ (1)

Distillation:
[illegible] = [illegible]
[illegible] = [illegible]

(i) Hexane and heptane are nearly ideal and form an ideal solution.

(a) Define an ideal solution. (1mark)
This is a solution which tends to ... [illegible] of ... [illegible] forces between the molecules of the components.

(ii) The vapour pressures of pure hexane and pure heptane are 56000 Nm^-2 and 24000 Nm^-2 at 25°C. Calculate the mole fraction of hexane in vapour above an equimolar mixture of hexane and heptane. (3marks)

$P_T = P_{hexane} + P_{heptane}$

$P_{hexane} = P^o_{hexane} \times X_{hexane}$

$= (56000 \times \frac{1}{2}) = 28000\ Nm^{-2}$

$P_{heptane} = (24000 \times \frac{1}{2}) = 12000\ Nm^{-2}$

$P_T = 28000 + 12000 = 40000\ Nm^{-2}$

$X_{heptane} = \frac{P_{heptane}}{P_{total}}$

$X_{heptane} = \frac{12000}{40000} = 0.3$

% mole fraction heptane is 30%

(iii) What would be the distillate if the mixture was distilled. Give reason for your answer. (1mark)
- Hexane because it has a higher vapour pressure at any given temperature.

Observation:

CH_3COO^- – No observable change ✓ (0.2)

$^-O\underset{O}{\overset{}{C}}-\underset{O}{\overset{}{C}}O^-$ – Purple solution turns colourless. ✓

0.6

8 Heptane and Hexane are totally miscible and form an ideal solution.

(a) Define an ideal solution. (1 mark)

This is a solution where there is complete uniformity of chemical and adhesive forces between the molecules of the components. ✓ (1)

(b)(i) The total vapour pressures of pure hexane and pure heptane are 56000 Nm^{-2} and 24000 Nm^{-2} at 50°C. Calculate the mole fraction of heptane in vapour above an equimolar mixture of hexane and heptane. (3 marks)

$P_T = P_{Hexane} + P_{Heptane}$ ✓+

$P_{Hexane} = P^o_{Hexane} \times \chi_{Hexane}$ ✓+

$= (56000 \times \frac{1}{2}) = 28000\ Nm^{-2}$

$P_{Heptane} = (24000 \times \frac{1}{2}) = 12000\ Nm^{-2}$ } ✓+ (03)

$P_T = 28000 + 12000 = 40000\ Nm^{-2}$ ✓+

$\chi_{Heptane} = \frac{P_{Heptane}}{P_{Total}}$ ✓+

$\chi_{Heptane} = \frac{12000}{40000} = 0.3$ ✓+

% mole fraction Heptane is 30%

(ii) What would be the distillate if the mixture was distilled. Give a reason for your answer. (1 mark)

– Hexane ✓+ because it has a higher (01) vapour pressure at any given temperature. ✓+

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Question __________ Do not write in this margin

9 The reaction below occurs when two half cells are connected.

$2MnO_4^-{}_{(aq)} + 5Pb^{2+}_{(aq)} + 2H_2O_{(l)} \longrightarrow 2Mn^{2+}_{(aq)} + 5PbO_{2(s)} + 4H^+_{(aq)}$

a (i) Write the equation of reaction occurring at the

(i) Anode (1mark)

$Pb^{2+}_{(aq)} + 2H_2O_{(l)} \longrightarrow PbO_{2(s)} + 4H^+_{(aq)} + 2\bar{e}$ ✓ (1)

(ii) Cathode. (1mark)

$MnO_4^-{}_{(aq)} + 8H^+_{(aq)} + 5\bar{e} \longrightarrow Mn^{2+}_{(aq)} + 4H_2O_{(l)}$ ✓ (1)

(b) (i) Write the cell notation for the two combined cells. (1mark)

$Pb^{2+}_{(aq)}; H_2O \,|\, PbO_2 \,|\, H^+ \,||\, MnO_4^-; H^+; Mn^{2+}; H_2O \,|\, Pt$ ✓ (1)

(ii) Calculate the emf of the cell if the standard reduction potentials for the anode and cathode are +1.46V and +1.51V respectively. (1½ marks).

$Emf = E^\ominus_{RHE} - E^\ominus_{LHE}$ ✓

$= 1.51 - 1.46$ ✓ (1½)

$= +0.05V$ ✓

04½

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10

SECTION B (56 marks)

Attempt Six questions from this section. Question

When 20cm³ of a gaseous hydrocarbon A was exploded with 150cm³ of oxygen, the residual gas occupied 110 cm³. After shaking the residual gas with aqueous sodium hydroxide, the final volume was 30cm³.

(a) Determine the molecular formular of A. (3marks)

$C_xH_{y(g)} + (x + y/4)O_{2(g)} \longrightarrow xCO_{2(g)} + y/2\ H_2O_{(l)}$

1 volume	$(x + y/4)$ volume	x volume
20cm³	(150 − 30)cm³	80 cm³
$\frac{20cm^3}{20cm^3}$	$\frac{120cm^3}{20cm^3}$	$\frac{80cm^2}{20cm^3}$ (03)
1	6	4

$x = 4$ $\quad x + y/4 = 6 \therefore y = 6$

Molecular formular is C_4H_6

(b) Name six isomers of A. (3marks)

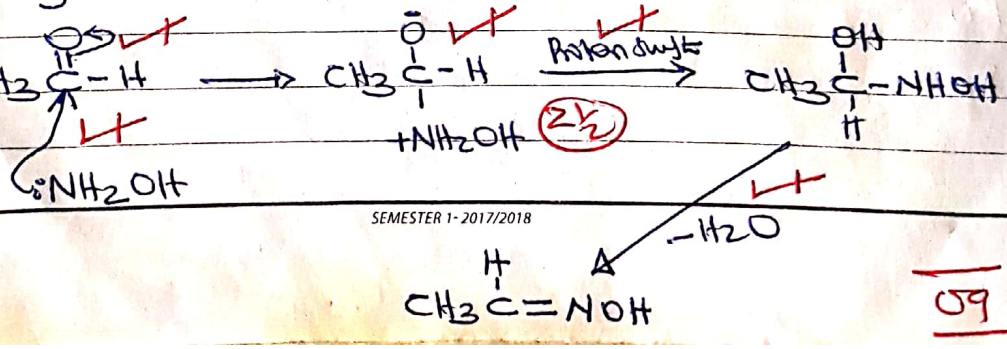
But-1-ene
Cis but-2-ene
trans but-2-ene (03)
2-Methyl propene
Cyclobutane
Methyl cyclopropane

(c)(a) Ozonolysis of A yielded one product B which gave a positive tests with Iodoform test.

(i) Identify A (½ mark)

Trans or cis but-2-ene. (½)

(ii) Write a mechanism of reaction between B and ~~NH_2NHOH~~ Hydroxylamine ($HONH_2$). (2½ marks).



(2½)

09

11 (a) Define the following terms.

(i) First ionisation energy. (1mark)

This is the energy required to remove one mole of an electron from a gaseous atom to form a unipositively charged gaseous ion at standard conditions. ✓(1)

(ii) Atomisation Energy (1mark)

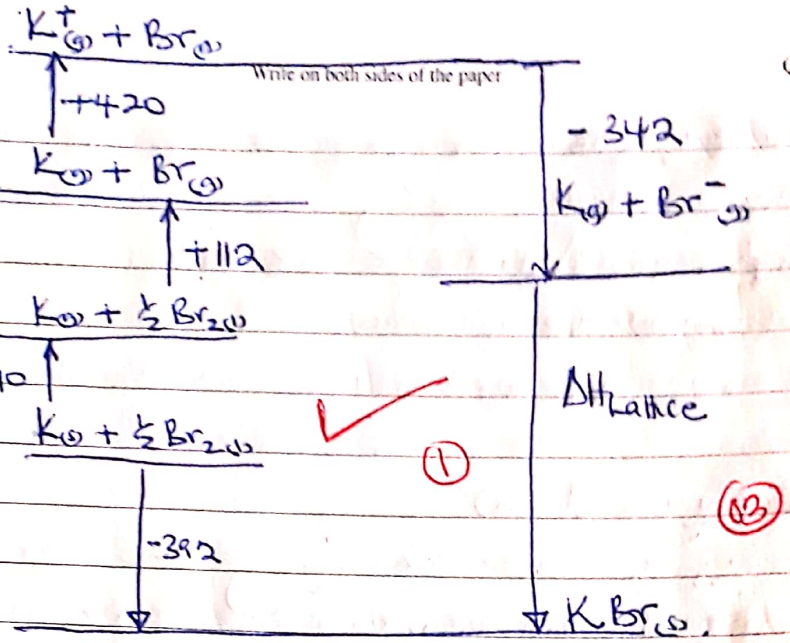
This is the energy required to form one mole of gaseous atoms from an element at standard conditions. ✓(1)

(iii) Lattice energy. (1mark)

This is the energy released when one mole of an ionic crystal lattice is formed from its constituent gaseous ions at standard conditions. ✓(1)

(b) Using the information below draw an energy level diagram and use it to calculate the lattice energy of potassium bromide. (3marks)

Reaction	$\Delta H / KJmol^{-1}$
$K_{(s)} + \frac{1}{2}Br_{2(l)} \rightarrow KBr_{(s)}$	-392
$K_{(s)} \rightarrow K_{(g)}$	+90
$K_{(g)} \rightarrow K^+_{(g)} + \bar{e}$	+420
$\frac{1}{2}Br_{2(l)} \rightarrow Br_{(g)}$	+112
$Br_{(g)} + \bar{e} \rightarrow Br^-_{(g)}$	-342.



(1) (1) (1) (03)

$\Delta H_{lattice} = +342 - 420 - 112 - 90 - 392$

$= -672\ kJmol^{-1}$

(c) The values of the lattice energy of the other potassium halides are

Compound	KF	KCl	KI
Lattice energy / $kJmol^{-1}$	-813	-710	-643

Explain the trend in the values lattice energy of potassium halides. (3marks)

From potassium fluoride to potassium iodide, lattice energy becomes less exothermic. This is because as the ionic radius of the halide ion increases, the charge density decreases, the attraction to the positive potassium ion also decreases, thus less energy is released on forming the crystal lattices. (03)

09

2 The behaviour of the hydride of elements from sodium to chlorine with water is summarised below.

~~NaH MgH_2 AlH_3 SiH_4 PH_3~~
~~react with water No reaction reacts~~
~~forms alkaline solution~~

NaH, MgH_2, AlH_3	React with water forming alkaline solution
SiH_4	No reaction with water
PH_3	Reacts forming slightly alkaline solution.
H_2S	reacts forming slightly acidic solution
HCl	Reacts to form an acidic solution.

(a) Write equation of reaction between sodium hydride and hydrogen sulphide with water. (3 marks)

$NaH_{(s)} + H_2O_{(l)} \longrightarrow NaOH_{(aq)} + H_{2(g)}$ ✓ ✓ (03)

$H_2S_{(g)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HS^-_{(aq)}$ ✓ ✓

(b) Explain why

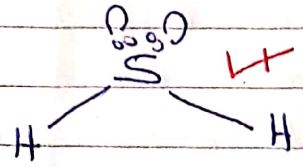
(i) the hydride of silicon does not react with water (2½ marks)

Silicon hydride is a simple molecular compound which is non polar because it lacks lone pair of electrons and silicon and hydrogen have similar electronegativity values. thus has no attraction for water molecules. (02½)

(ii) the reaction solution of phosphine in water is slightly alkaline. (2½ marks)

Phosphine is a simple molecule in which the phosphorus atom has a lone pair of electrons which attracts the hydrogen ion from the water molecule. More water molecules dissociate leading to the formation of hydroxyl ion in solution making the solution alkaline (02½)

(c) Draw the and name the shape adopted by the hydride of sulphur. (1mark)



V-shape

13. Benzoic acid is a weak monobasic acid with a pK_b of 9.806.

(a) Calculate

(i) pH of a 0.02M benzoic acid solution. (4marks)

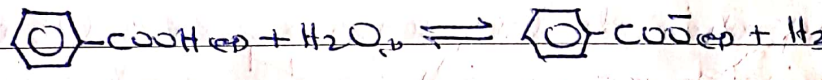
$pK_a + pK_b = 14$

$pK_a = (14 - 9.806) = 4.194$

$pK_a = -\log K_a = 4.194$

$\log K_a = -4.194$

$K_a = 10^{-4.194} = 6.4 \times 10^{-5}$ mol dm^{-3}



$K_a = \frac{[\text{C}_6\text{H}_5\text{COO}^-][H_3O^+]}{[\text{C}_6\text{H}_5\text{COOH}]}$ (04)

At equilibrium $[\text{C}_6\text{H}_5\text{COO}^-] = [H_3O^+]$

Assumption: Degree of dissociation of $\text{C}_6\text{H}_5\text{COOH}$ is very small; $[\text{C}_6\text{H}_5\text{COOH}] = 0.02M$.

$\sqrt{[H_3O^+]^2} = \sqrt{6.4 \times 10^{-5} \times 0.02}$

$[H_3O^+] = 1.131 \times 10^{-3}$ M mol dm^{-3}

$pH = -\log [H_3O^+]$

$= -\log(1.131 \times 10^{-3})$

$= 2.946$

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Question

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(ii) pH of a solution containing 7.2g of sodium benzoate in 1 dm^3 of 0.02M benzoic acid. (3marks)

Mass of C_6H_5COONa = (12x6)+(1x5)+(1x12)+(2x16)+(1x23) = 144

moles C_6H_5COONa = $\frac{7.2}{144}$ = 0.05M.

$K_a = \frac{[C_6H_5COO^-][H^+]}{[C_6H_5COOH]}$.

03

Complete dissociation of salt: $[C_6H_5COONa] = [C_6H_5COO^-] = 0.05$

$6.4 \times 10^{-5} = \frac{0.05\,[H^+]}{0.02}$

$[H^+] = \frac{6.4 \times 10^{-5} \times 0.02}{0.05} = 2.56 \times 10^{-5}$

$pH = -\log[H^+] = -\log(2.56 \times 10^{-5}) = 4.5992$.

(c) State

(i) What would happen to the pH of solution in a(ii) if $1cm^3$ of 0.01M sodium hydroxide solution is added. (1mark)

- The pH remains approximately constant. (1)

(ii) One importance of the solution in a(ii). (1mark)

- Regulation of pH of blood. (1)
- Maintain pH constant for industrial processes.

09

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14(a) Explain the meaning of the following.

(i) activated state (1mark)

- This is the state of the reacting molecules at their position of maximum energy during the course of reaction. ✓ (1)

(ii) Activation energy (1mark)

- This is the minimum energy required by reactants in order for the reaction to occur. ✓ (1)

(b) Two gases X and Y react according to the following equation

$X_{(g)} + 2Y_{(g)} \longrightarrow XY_{2(g)}$ $\Delta H = +ve$

The following data was obtained

Experiment Numbers	Initial concentration / g/dm³ X	Y	Initial rate of formation XY_2 / mol dm⁻³ s⁻¹
1	0.10	0.10	0.0001
2	0.10	0.20	0.0004
3	0.10	0.30	0.0009
4	0.20	0.10	0.0001
5	0.30	0.10	0.0001

(i) Determine the order of reaction with respect to X and Y. (2marks)

X: Order of reaction with respect to X is zero because ✓ (01) doubling the concentration of X has no effect ✓ on the rate of reaction.

Y: Order of reaction with respect to Y is two because ✓ (01) doubling the concentration of Y, increases the rate four times. ✓

(ii) Write the rate equation for the reaction between X and Y (1mark)

$Rate = K[X]^0[Y]^2$ ✓ (1)

(iii) Using the rate equation, predict the possible mechanism for this reaction. (1mark)

$Y + Y \xrightarrow{\text{slow}} Y_2$ ✓

$X + Y_2 \xrightarrow{\text{very fast}} XY_2$ ✓ (01)

(c) Calculate the rate constant and state its unit. (3 marks)

Rate = $K[Y]^2$ ✓

$K = \frac{0.0001}{(0.10)^2}$ ✓ $= 0.01$ ✓ $mol^{-1}\ dm^3\ s^{-1}$ (02)

(d) State one reason why it is important to obtain orders of reaction and rate equation. (1 mark)

- Explore and predict reaction mechanism ✓ (1)
- Understand how reaction occurs.

09

15 (a) Complex ion can sometimes exhibit isomerism and the compound

(a) The compound $[Co(NH_3)_5Br]^{2+}SO_4^{2-}$ is isomeric with the compound $[Co(NH_3)_5SO_4]^+Br^-$.

(i) Name the complexes. (1 mark)

$[Co(NH_3)_5Br]^{2+}SO_4^{2-}$ Pentaamminemonobromo Cobalt (III) Sulphate ✓ (½)

Monobromo pentaammine cobalt (III) Sulphate

$[Co(NH_3)_5SO_4]^+Br^-$ Pentaammine Sulphato Cobalt (III) bromide

Sulphatopentaammine cobalt (III) bromide. ✓ (½)

(ii) Write a reagent that can be used for each complex, name a reagent that can give a positive test with it. State what is observed in each case. (4 marks)

$[Co(NH_3)_5Br]^{2+}SO_4^{2-}$

Reagent: Barium nitrate solution ✓ (1)

Observation: blue precipitate. ✓ (1)

$[Co(NH_3)_5SO_4]^+Br^-$

Reagent: Silver nitrate solution. ✓ (1)

Observation: Pale yellow precipitate. ✓ (1)

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Question

(a) State two reasons why Cobalt can form complexes. (2marks)

- Has Vacant 3d-orbitals ✓ ✓ (01)
- It forms ion with a high charge density.

(b)(i) Explain why several compounds of Copper (I) compounds are white. (2marks)

- Copper (I) compounds contain Copper (I) ion which with electron structure $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$. The Copper (I) ion has a fully filled 3d-orbital. Electron transitions (02) are therefore impossible within the 3d-levels of Copper (I) ion thus Copper (I) compounds are white.

(ii) Write an equation for the reaction between copper sulphate and potassium iodide. (1mark).

$2Cu^{2+}_{(aq)} + 4I^-_{(aq)} \longrightarrow 2CuI_{(s)} + I_{2(aq)}$ ✓ (1)

05

16

16 (a) Distinguish between addition and condensation polymerisation. (2 marks)

Addition polymerisation is where a large number of unsaturated molecules join together to form a single compound with a higher molecular mass but with the same empirical formular as the monomer. While (1)

Condensation polymerisation is where a large molecule is formed by combining two monomers which are bifunctional with elimination of small molecule like water, ammonia, carbondioxide, methanol. (1)

(ii) State two factors that affects properties of a polymer. (1 mark)

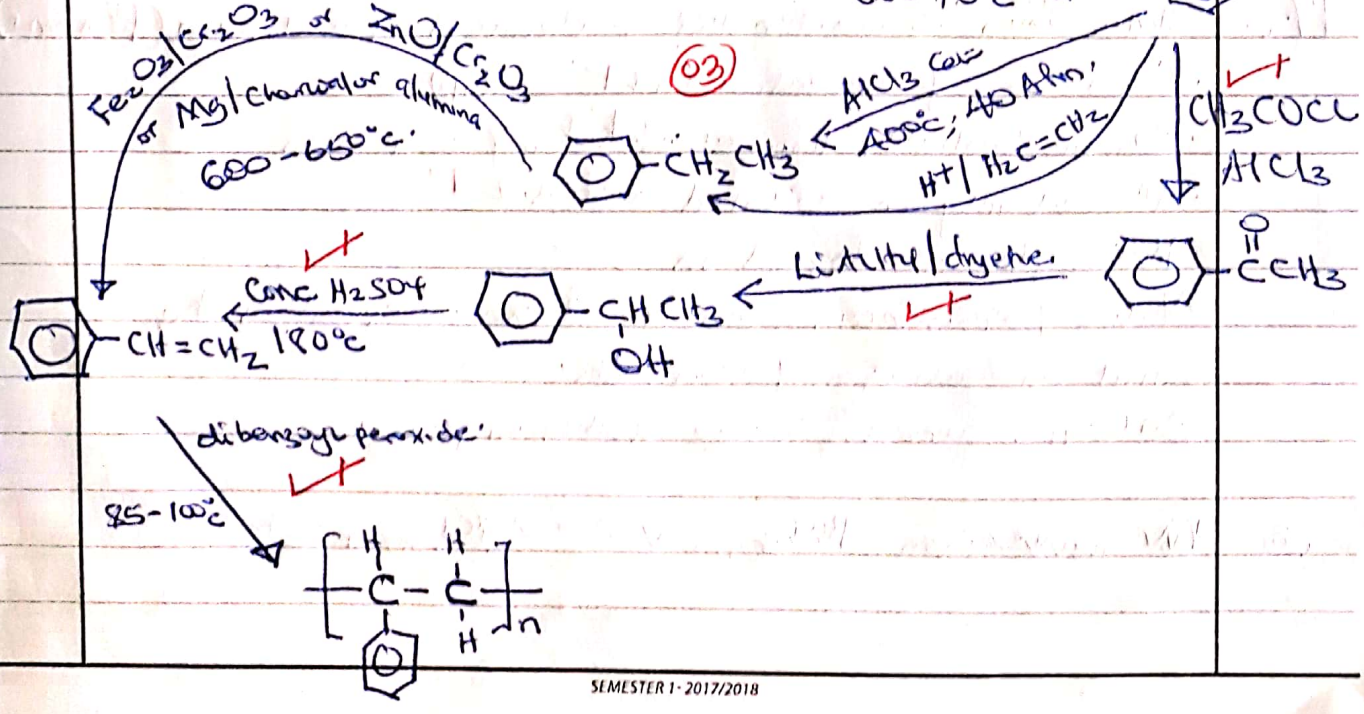
- Chain length
- Intermolecular forces.
- Branching
- Cross linking

(07)

(b) Polystyrene is a synthetic polymer formed by addition polymerisation.

(i) Write equations to show how Polystyrene can be prepared starting from calcium carbide. (3 marks)

$CaC_2 \xrightarrow{H_2O} HC\equiv CH \xrightarrow[60-70^\circ C]{\text{Complex organo-nickel}}$ 



(c) At 20°C the osmotic pressure of a solution of ~~polystyrene~~ polystyrene of concentration $1 g dm^{-3}$ is $101 Nm^{-2}$. Calculate the number of monomer units in the polymer. (3 marks)

$$\Pi V = \frac{m}{Mr} RT$$ ✓+

$$101 \times 1 \times 10^{-3} = \frac{1}{Mr} \times 8.314 \times 293$$ ✓+

$$Mr = \frac{1 \times 8.314 \times 293}{101 \times 1 \times 10^{-3}} = 24118.83.$$ ✓+ (03)

Monomer Units = $(8 \times 12) + (8 \times 1) = 104$.

The number of monomers = $\frac{\text{Polymer molar mass}}{\text{Monomer molar mass}}$ ✓+

$$= \frac{24118.83}{104}$$ ✓+

$$= 232.$$ ✓+

04

17 (a) State three characteristics of chemical equilibrium (1½ marks)

- Constancy of Concentration ✓+ (01½)
- Can be initiated from either side of the equation ✓+
- Attained only in a closed vessel. ✓+
- Value doesn't depend on
- Value of equilibrium constant doesn't depend on the initial concentration of reactants.
- Catalyst cannot change equilibrium point.

(b) For the reaction $PCl_{5(g)}$ ⇌ $PCl_{3(g)} + Cl_{2(g)}$

Write on both sides of the paper

Question

17(b) The equilibrium constant K_c for the dissociation of phosphorus pentachloride is 33.3 mol dm^{-3} at 760K. 1.0g of phosphorus pentachloride is injected into a 500 cm^3 evacuated flask and heated to come to equilibrium. Calculate the percentage of phosphorus pentachloride that will dissociate at equilibrium. (4 Marks)

Initial moles PCl_5 = $\frac{1}{208.5}$ = 0.0048 mole.

$PCl_5(g) \longrightarrow PCl_3(g) + Cl_2(g)$

Initial concentration PCl_5 = $\left(\frac{0.0048}{0.5}\right)$ = 0.0096M

At equilibrium:

$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$

$(0.0096-x)$ $\quad x \quad x$

$$K_c = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{x \cdot x}{0.0096-x} = 33.3$$

$$\frac{x^2}{0.0096-x} = 33.3 \; ; \quad x = 9.597 \times 10^{-3}.$$

∴ Final concentration of PCl_5 = $(0.0096 - 9.597 \times 10^{-3})$

= 3×10^{-6} mol dm^3

% PCl_5 dissociated = $\left(\frac{0.0096 - 3\times10^{-6}}{0.0096} \times 100\right)$

= 99.9%.

(c) ~~State what would happen to the equilibrium concentration of PCl_5 if~~

(d)

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Write on both sides of the paper

Question [illegible]

(c) State what would happen to the value of K_p if (1½ marks)

(i) More PCl5 is added.

- K_p is unaffected. ✓+

(ii) Pressure is increased

- K_p is unaffected. ✓+

(iii) temperature is increased

K_c increases. ✓+

(1½)

(d) Explain why a compromise temperature of 450°C is used in the contact process. (2marks)

- The reaction for the formation of sulphur trioxide is exothermic ✓+ therefore it is favoured by a low temperature ✓+ but very low temperature leads to slows down the reaction ✓+ so a temperature where rate of reaction and equilibrium shifts toward right balance is used. ✓+

(02)

09