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P525/1

CHEMISTRY

Paper 1

April. /May. 2024

2 ¼ hrs.

CHEMISTRY DEPARTMENT

SAYIDINA ABUBAKAR SECONDARY SCHOOL- KABASANDA

S.6 END OF TERM ONE EXAMINATIONS 2024

CHEMISTRY

Paper 1

2 hours 45 minutes

INSTRYUCTION TO CANDIDATES:

- Answer **all** questions in section **A** and **six** questions in section **B**.
- **All** question must be answered in the space provided.
- Illustrate your answers with equation(s) where applicable.

Where necessary, use the following:

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

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

Standard temperature =273K

Standard pressure = $101325NM^{-2}$

For examiner's use only	
Section A	46
Section B	54
Total	100%

SECTION A (46MARKS)

Answer all questions in this section.

1. The standard electrode potential of some half cells reactions are given below:

Half cells	E^{θ}(V)
$Sn^{4+}(aq) + 2e \longrightarrow Sn^{2+}(aq)$	+ 0.15 Anode
$PbO_2(s) + 4H^+(aq) + 2e \longrightarrow Pb^{2+}(aq) + 2H_2O(l)$	+1.46 Cathode

(a). Write the overall equation for the cell reaction that occurs when the half cells are combined. (01½mks)

$PbO_2(s) + 4H^+(aq) + Sn^{4+}(aq) \longrightarrow Sn^{2+}(aq) + Pb^{2+}(aq) + 2H_2O(l)$ ✓✓

rej. Unbalanced equation.

rej. No or wrong physical state.

(b). Calculate the work done by the cell. (Faraday constant= 96500C) (03mks)

$E^{\theta}_{cell} = E^{\theta}_{cathode} - E^{\theta}_{anode}$ ✓

$= (+1.46) - (+0.15)$

$= +1.31V$ ✓ Deny: $+1.31$ ✓

From Gibbs free energy $= -nFE^{\theta}_{cell}$ ✓

$\Delta G^{\theta} = -2 \times 96500 \times 1.31$

$\Delta G^{\theta} = -252830J$ ✓

∴ The work done by the cell is $-252830J$ ✓

Deny: Without units.

Deny: With wrong units or without units.

(c). State whether the cell is feasible or not. Give a reason for your answer. (01mk)

It's feasible ✓ because the Gibbs free energy of the cell is negative ✓.

5½mks

2. Complete the following equations and write the accepted mechanism in each case.

(a) $CH_3CH_2CH(OH)CH_3 \xrightarrow[180^{\circ}C]{\text{conc. } H_2SO_4} CH_3CH{=}CHCH_3 + H_2O$ ✓

$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$ ✓ Deny: unbalanced equation.

$CH_3CH_2\underset{OH}{CH}CH_3 \longrightarrow CH_3CH_2\overset{+}{C}HCH_3 \xrightarrow{-H_2O} CH_3\overset{+}{C}{-}\overset{+}{C}HCH_3$

OH ✓ $\quad OH_2 \quad H \quad OSO_3H$

Deny: When lone pairs of electrons are not shown clearly and stop marking emphasize: correct chemical symbols

Arrow must touch the bond

$CH_3CH{=}CHCH_3$ (02½mks)

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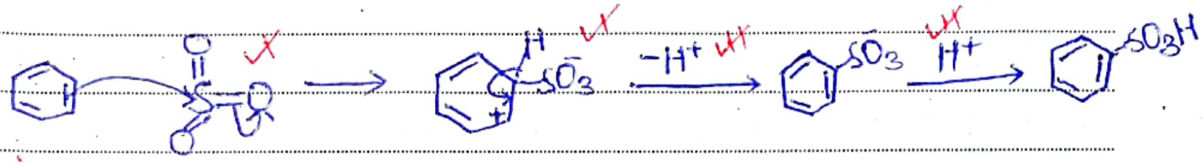
(b) C_6H_6 conc. H_2SO_4 ⟶ $C_6H_5SO_3H$ ✓

Heat

$2H_2SO_4 \rightleftharpoons SO_3 + HSO_4^- + H_3O^+$ ✗



Reject and stop marking; hanging bonds and arrows. (03mks)

05½mks

3. (a) (i) Explain what is meant by the order of chemical reaction. (01mks)

Order of chemical reaction is the sum of the powers to which the molar concentrations of the reactants are raised in the experimental rate equation.

Rej. When is missing out technical terms.

(ii) Name two methods used to determine order of reaction. (01mks)

Initial rate method ✗

Graphical method ✗

(b) The results obtained for the kinetics of the decomposition of nitrogen (V) oxide are given in the table below.

	[N2O5] (moldm^{-3})	Initial rate (moldm^{-3}s^{-1})
1.	1.6 x 10^{-3}	0.12
2.	2.4 x 10^{-3}	0.18
3.	3.2 x 10^{-3}	x

Calculate the value of x. (03½mks)

When the concentration of nitrogen (V) oxide is multiplied by 1.5, the rate of reaction also increases by 1.5 times implying that the order of the above reaction is one ✓

Consider experiment 2 and 3.

$0.18 = k(2.4 \times 10^{-3})^1$ ✗ ——(i)

$x = k(3.2 \times 10^{-3})^1$ ✗ ——(ii).

eqn (ii) ÷ eqn (i).

$\frac{x}{0.18} = \frac{3.2 \times 10^{-3}}{2.4 \times 10^{-3}}$

$x = \frac{3.2 \times 10^{-3} \times 0.18}{2.4 \times 10^{-3}}$ ✗

$x = 0.24$ ✓

05½mks

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4. The table below shows the melting points of the oxides of group (II) elements.

Oxides	BeO	MgO	CaO	SrO	BaO
Melting points of oxides (°C)	2530	2800	2580	2430	1928

Explain the trend in the melting points of these oxides. (04mks) Emphasize technical terms.

Melting point increases from beryllium oxide to magnesium oxide and then decreases from magnesium oxide to barium oxide; Beryllium oxide has a lower melting point than expected because beryllium ion has a very small ionic radius, high polarising power and high charge density making beryllium oxide predominantly covalent hence bonds require less energy to break; The decrease from magnesium oxide to Barium oxide is because cationic radius increases, bond length increases, bond strength reduces reducing the amount of energy required to break the ionic bonds. 04mks

5. A compound Q contains 60% carbon, 13.3% hydrogen and the rest being oxygen. W 0.698g of Q was dissolved in 100g of a solvent, there was a 0.19°C depression in freezing point of a solvent. (Kf of the solvent = 1.63°CKg^{-1}mol^{-1}):

(a) Calculate the simplest formula of Q. (02mks)

Percentage by mass of oxygen = 100 − (60 + 13.3) = 26.7% should be shown clearly. Absent!

Elements;	C	:	H	:	O
Percentage by mass;	60	:	13.3	:	26.7
Moles;	60/12	:	13.3/1	:	26.7/16
Simplest ratio;	5/1.66875	:	13.3/1.66875	:	1.66875/1.66875
	3	:	8	:	1

Empirical formula of Q is C_3H_8O

(b) Determine the molecular formula of Q. (03mks)

100g of solvent dissolve 0.698g of Q

1000g of solvent dissolve $\left(\frac{1000 \times 0.698}{100}\right)$ g of Q

= 6.98g of Q

0.19°C is depression in freezing point caused by 6.98g of Q

1.63°C is depression in freezing point caused by $\left(\frac{1.63 \times 6.98}{0.19}\right)$ g of Q

= 59.88g

Molecular mass of Q = 60g Rej. without unit

$(C_3H_8O)_n = 60$

$n = 1$

Molecular formula C_3H_8O

(c) Write the structural formula and the name of compound Q. (01mk)

$CH_3CH_2CH_2OH$; Propanol

06mks

6. (a) Explain what is meant by a diagonal relationship. (01mk)

A diagonal relationship is the similarity in properties of elements in period 2 and their adjacent diagonally opposite neighbours in period 3 of the Periodic Table.

(b) Write the electronic configuration of the following elements:

(i) Beryllium. (01mk)

$1s^2 2s^2$ ✓

(ii) Aluminium. (01mk)

$1s^2 2s^2 2p^6 3s^2$ ✓

(c) State any two reasons as to why beryllium resembles aluminium in its properties. (02mks) −1mk for each wrong extra point.

Both beryllium and aluminium have the same electronegativity.

Both beryllium and aluminium have almost the same atomic radius.

Both beryllium and aluminium have almost the same polarising power.

05mks

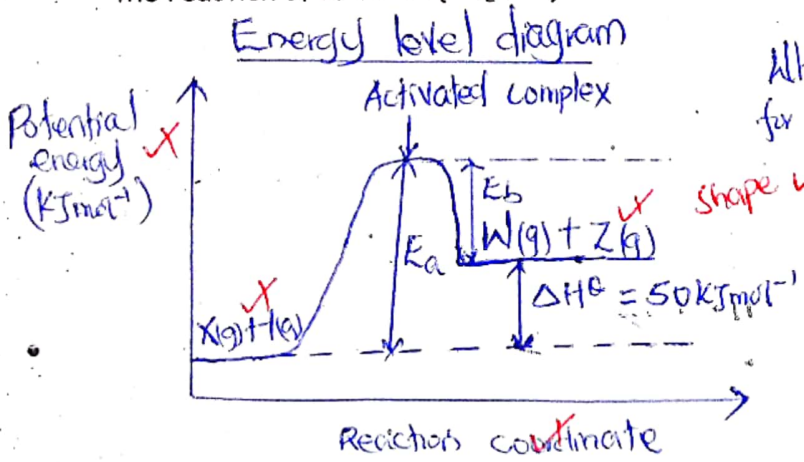
7. (a) Define the term activation energy. (01mk)

Activation energy is the minimum energy which is required to be possessed by reactants inorder to react and forms product.

(b) X and Y react to form W and Z according to the following equation.

$X(g) + Y(g) \longrightarrow W(g) + Z(g)$ Heat of a reaction= $+50 KJmol^{-1}$

(i) Draw a fully labelled potential energy versus reaction coordinate diagram for the reaction of X and Y. (02½mks)



Shape ✓

Where Ea is activation energy for the forward reaction

Eb is activation energy for the backward reaction

ΔHθ is enthalpy of reaction.

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(ii) Calculate the activation energy of the backward reaction (the activation energy for the forward reaction is +200KJmol^{-1}) (01½mks)

From $\Delta H^{\theta} = Ea - Eb$. ✓ | $Eb = +150 KJmol^{-1}$.

$+50 = +200 - Eb$ | ∴ Activation energy of the backward

$Eb = +200 - (+50)$ | reaction is $+150 KJmol^{-1}$. ✓

05mks

8. Complete the following equations and write the IUPAC names of the main organic product in each case.

(a) $CH_3CH_2CH_2COOH$ $\xrightarrow[\text{Heat}]{NaOH(s)/\ CaO(s)}$ $CH_3CH_2CH_3$ ✓ (01mk)

Name Propane. ✓ (0½mk)

(b) $CH_3CH=CHCH_3$ $\xrightarrow{1.\ O_3,\ CCl_4,\ <20^{\circ}C}$ $2CH_3CHO$ ✓ (01mk)

~~2. H_2O, Zn, CH_3COOH.~~ 2. H_2O, Zn, CH_3COOH.

Name Propanal. ✓ (0½mk)

(c) CH_3COCH_3 $\xrightarrow[H_2O]{NaBH_4}$ $CH_3\underset{OH}{\underset{|}{C}}HCH_3$ ✓ (01mk)

Name Propan-2-ol. ✓ (0½mk)

04½mks

9. (a) State the common oxidation states exhibited by elements in group (IV) of the Periodic Table. (01mk)

Group (IV) elements exhibit the +2 ✓ and +4 ✓ oxidation states.

(b). Discuss the reaction of the following group(IV) elements with dilute nitric acid.

(i) Tin.(02mks)

Tin is oxidized by cold dilute nitric acid to tin (II) nitrate and itself reduced to ammonium nitrate and water. -½mk; unbalanced equation

$4Sn(s) + 10HNO_3(aq) \longrightarrow 4Sn(NO_3)_2(aq) + NH_4NO_3(aq) + 3H_2O(l)$.

(ii) Lead. (02mks)

Dilute nitric acid oxidises lead to lead (II) nitrate and itself reduced to nitrogen monoxide and water.

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$3Pb_{(s)} + 8HNO_{3(aq)} \longrightarrow 3Pb(NO_3)_{2(aq)} + 2NO_{(g)} + 4H_2O_{(l)}$ ✓

deduct: ½ mk for unbalanced equation and wrong physical states. Accept: Ionic equation. 05mks

SECTION B (54 MARKS)

Answer **six** question from this section

10. Name one functional group that can be identified using each of the following reagents. In each case state what would be observed and write equation for the reaction that would take place

(a) Bromine water: Rej. double bond.

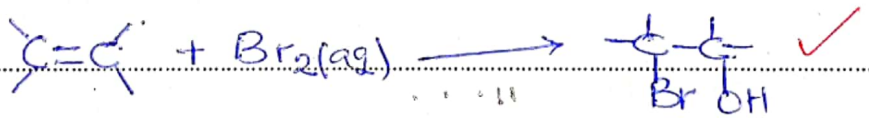
Functional group.(01mk)

Carbon to carbon double bond. ✓

Observation.(01mk)

The reddish-brown colour of bromine water turns colourless. ✓ Rej. decolourless.

Equation.(01mk)

 ✓

(b) 2, 4-dinitrophenyl hydrazine:

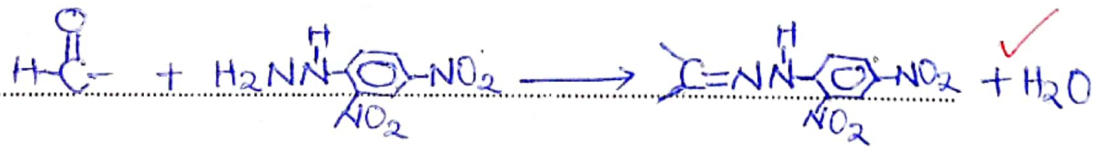
Functional group.(01mk)

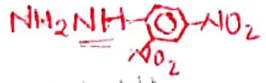
Carbonyl group ✓ Deny. ketone or aldehyde.

Observation.(01mk) Accept: Orange

Yellow precipitate formed. ✓

Equation.(01mk)

 ✓

Reject; 

(c) Sodium carbonate:

Functional group.(01mk)

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Rej. Carboxyllic group.

Carboxyl group. ✓

Observation. (01mk)

Check spelling of efferiescence

Bubbles of a colourless gas ✓

Equation. (01mk)

$2(-COOH)(aq) + Na_2CO_3(aq) \longrightarrow 2(-COONa)(aq) + CO_{2(g)} + H_2O_{(l)}$ ✓

Ignore physical states

Rej. When not balanced.

09mks

11. (a) Define the term boiling point constant of a substance. (01mk)

This is the elevation in boiling point caused when one mole of a non-ionizing and non-volatile solute is dissolved in 1000g of a solvent ✓

(b) State any two colligative properties of a solution. (02mks)

-1mk for each extra wrong property.

Osmotic pressure of a solution. ✓ reject: solvent

Elevation in boiling point of a solvent. ✓ reject: solution.

(c) 2.00g of phosphorus raise the boiling point of 37.4g carbon disulphide by 1.003°C.

(i) Calculate the molar mass of phosphorus in carbon disulphide. (Kb for carbon disulphide is 2.35°Cmol^{-1}Kg^{-1}) (03mks)

- Follow first principle
- Rej. use of formula.

37.4g of Carbon disulphide dissolve 2.00g of phosphorus ✓

1000g of Carbon disulphide dissolve $\left(\frac{2 \times 1000}{37.4}\right)$g of phosphorus ✓

1.003°c is elevation in boiling point caused by 53.4759g ✓

2.35°c is elevation in boiling point caused by $\left(\frac{2.35 \times 53.4759}{1.003}\right)$g ✓

∴ Molar mass of phosphorus in carbon disulphide is 125.29g ✓ -1mk without units. Wrong units = 125.29g

(ii). Hence determine the molecular formula of phosphorous in carbon disulphide. (P= 31) (02mks)

$P_n = 125.29$ ✓ | $n = 4$ ✓

$31n = 125.29$ | ∴ Molecular formula of phosphorus in Carbon disulphide is P_4 ✓

(iii) Comment on the results in c (iii) above. (01mk)

Phosphorous exists as a tetratomic molecules in Carbon disulphide. ✓

09mks

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12. Write equations to show how the following conversion can be effected.

(a) CH_4 from $H_2C=CH_2$ (03mks)

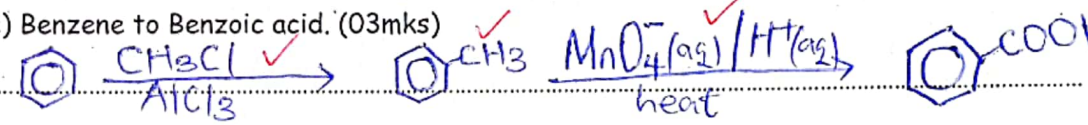
$H_2C=CH_2 \xrightarrow[heat]{H^+/H_2O} CH_3CH_2OH \xrightarrow[heat]{H^+/Cr_2O_7^{2-}} CH_3CHO \xrightarrow[heat]{H^+/Cr_2O_7^{2-}} CH_3COOH \xrightarrow[heat]{\text{Soda lime}} CH_4$

Stop marking: Wrong / missing condition / Wrong product.
Emphasize: Correct chemical symbol.

(b) CH_3CH_2COOH from $CH_3CH=CH_2$. (03mks)

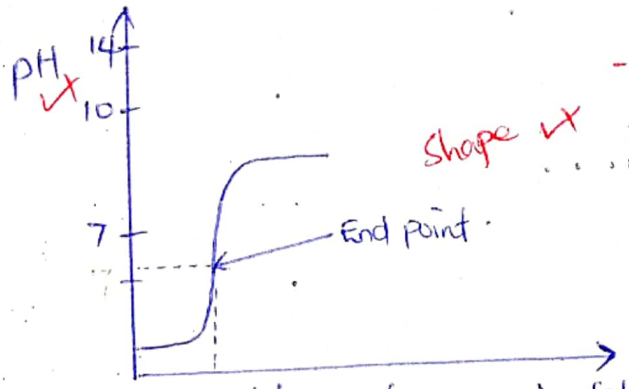
$CH_3CH=CH_2 \xrightarrow[\text{Organic peroxide}]{HBr} CH_3CH_2CH_2Br \xrightarrow[heat]{NaOH(aq)} CH_3CH_2CH_2OH \xrightarrow[heat]{H^+/Cr_2O_7^{2-}} CH_3CH_2CHO \xrightarrow[heat]{H^+/Cr_2O_7^{2-}} CH_3CH_2COOH$

(c) Benzene to Benzoic acid. (03mks)



Accept any other correct alternative / pathway and award accordingly. 09mks

13. (a) (i) Sketch a graph to show the pH change when hydrochloric acid is titrated with ammonia solution. (01½mks)



Shape
- Largest part of the steep part should be below 7
- The highest point should be below 10.

Deny: Without word solution. is

(ii) Explain the shape of your sketch graph in (a) (i). (03½mks)

Initially the pH is low because of the high concentration of hydrogen ions from complete ionization of hydrochloric acid which is a strong acid; The pH then gradually rises as ammonia solution is added because hydrogen ions are being neutralised; This is followed by a sharp rise in pH with little ammonia solution added meaning that the end point has been reached; The pH of solution at end point is less than 7 because the ammonium chloride salt formed undergoes hydrolysis forming hydrogen ions; after end point there is gradual rise in pH due to excess ammonia solution added.

(b) Calculate the pH of the resultant solution formed when $10cm^3$ of a 0.1M sodium hydroxide is added to $25cm^3$ of a 0.1M ethanoic acid at 25°C.

(Dissociation constant of ethanoic acid at 25°C=1.8×10^{-5} $moldm^{-3}$)(04mks)

Number of moles of NaOH added $= \left(\frac{0.1\times10}{1000}\right)$ ✓

$= 1\times10^{-3}$ moles

Number of moles of CH_3COOH added $= \frac{0.1\times25}{1000}$ ✓

$= 2.5\times10^{-3}$ moles

$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$ ✓

Number of moles of ethanoic acid that reacted $= 1.0\times10^{-3}$ moles

Excess acid $= 1.5\times10^{-3}$ moles ✓

Number of moles of salt formed $= 1\times10^{-3}$ moles

Concentration of CH_3COOH in resultant solution $= \frac{1000\times1.5\times10^{-3}}{35}$ ✓

$[CH_3COONa]$ resultant solution $= \frac{1000\times1.0\times10^{-3}}{35}$ ✓

$= 0.0286M$ ✓

Accept: Correct alternative

From $pH = pK_a + \log\frac{[salt]}{[acid]}$ ✓

$pH = -\log 1.8\times10^{-5} + \log\frac{0.0286}{0.0428}$

$pH = 4.57$ ✓

09mks

14. The table below shows the ionization energies of Group VII elements.

Element	F	Cl	Br	I
Atomic radius(nm)	0.072	0.099	0.114	0.133
Ionic radius (nm)	0.136	0.181	0.195	0.216

(a) Define the term atomic radius. (02mks)

Atomic radius is half the internuclear distance between two atoms in a covalently bonded diatomic molecule. ✓

(b) State and explain the trend in atomic radius of the elements. (04mks)

Atomic radius increases from fluorine to iodine; This is because from fluorine to iodine, nuclear charge increases and also screening effect increase. But an increase in the screening effect due to addition of an extra energy level outweighs the increase in the nuclear charge, hence the effective nuclear attraction for the outer most electrons decreases, making the electrons far apart and weakly attracted by the nucleus, hence increase in atomic radius.

(c) Explain why the ionic radius is larger than the atomic radius of the corresponding neutral atom for each element. (03mks)

The ions are formed by gaining electrons; The number of electrons became greater than the number of existing protons. Screening effect increases; Effective nuclear charge reduces. The electrons become more strongly repelled by the nucleus than they are attracted.

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Hence making ionic radius of the element larger than their respective atomic radius! 09mks

15. (a) when 0.1g of aluminium chloride was vaporized at 350°C and pressure of 1 atmosphere, 19.2cm^3 of vapour was formed.

(i) Calculate the relative molecular mass of aluminium. (02mks)

Molecular mass: $M_r = \frac{mRT}{PV}$

$= \frac{0.1 \times 8.31 \times (350+273)}{101325 \times 19.2 \times 10^{-6}}$

$= 266.12g$

∴ Relative molecular mass of aluminium is 266.12

Rej. With units.

(ii) Write the molecular formula of aluminium chloride in the gaseous state at 350°c. (Al =27, Cl =35.5). (02mks)

$(AlCl_3)_n = 266.12$

$27n + 3 \times 35.5n = 266.12$

$n = 2$

∴ Molecular formula is Al_2Cl_6

(b) Aluminium chloride is normally contaminated by traces of iron (III) chloride.

(i) Name one reagent that can be used to detect the presence of iron (III) ion in a contaminated solution of aluminium chloride. (01mk)

Ammonia solution Rej. Without solution.

(ii) State what would be observed if the contaminated aluminium chloride solution was treated with the reagent you have named in b (i). (0½mk)

A brown precipitate forms.

(c). Water was added dropwise to aluminium chloride.

(i) State what was observed.(0½mk)

White solid dissolves forming a cloudy solution and misty fumes.

(ii) Write equation for the reaction that took place. (01½mks)

$Al(H_2O)_6^{3+}(aq) + H_2O(l) \rightleftharpoons [Al(H_2O)_5OH]^{2+}(aq) + H_3O^+(aq)$

Accept: correct alternative and award accordingly.

(d) State one use of aluminium chloride in organic synthesis. (01½mks)

Use as a catalyst in halogenations and alkylation of benzene.

09mks

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16. (a) Explain the term partition coefficient. (02mks)

check: Technical terms.

This is the constant ratio of the molar concentrations of a non-volatile solute in a mixture of two immiscible solvents in contact when equilibrium is established at a given temperature provided the solute remains in the same molecular state.

(b) State two conditions under which partition coefficient is valid. (02mks)

Solvents should be immiscible. - Temperature must be constant

Solution should be dilute. -1mk for @ wrong condition.

(c) A solute Q is three times as soluble in ethoxyethane as in water. An aqueous solution containing 4.5g of Q per litre of a solution was shaken by ethoxyethane in a separating funnel. Calculate the mass of Q that was extracted when the solution was shaken:

(i) With 100cm^3 of ethoxyethane. (02mks)

Let $[Q]_{H_2O} = x$

$[Q]_{ether} = 3x$

$K_D = \frac{[Q]_{ether}}{[Q]_{H_2O}}$

$K_D = \frac{3x}{x}$

$K_D = 3$

Let a be mass of Q extracted by the 100cm^3 of ethoxyethane

$3 = \frac{a/100}{(4.5-a)/1000}$

$3 = \frac{10a}{4.5-a}$

$a = 1.035g$

∴ Mass of Q extracted by 100cm^3 of ethoxyethane is 1.035g

(ii) Twice with 50cm^3 of ethoxyethane. (02mks)

Let $[Q]_{H_2O} = x$

Then $[Q]_{ether} = 3x$

$K_D = \frac{[Q]_{ether}}{[Q]_{H_2O}}$

$K_D = \frac{3x}{x}$

$K_D = 3$

Let y be mass of Q extracted by the first 50.0cm^3 portion of ethoxyethane

$3 = \frac{y/50}{(4.5-y)/1000}$

$y = 0.557g$

∴ First portion extracted 0.557g

Mass of Q remaining in water = 4.5 - 0.557 = 3.913g

Let m be mass of Q extracted by 2nd portion of ethoxyethane

$3 = \frac{m/50}{(3.913-m)/1000}$

$m = 0.510g$

∴ Total mass extracted by two successive 50cm^3 portion of ethoxyethane is $(0.557 + 0.510) = 1.097g$

(d) Comment on your results in (c) above. (01mk)

More mass of Q is extracted when using smaller portion of ethoxyethane (50cm^3) seperately than using the whole of the liquid in one extraction.

01mks

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17. Sodium, aluminium, silicon and phosphorous are the elements in period 3 of the Periodic Table.

(a) For each element, write the formula and name the structure of the oxide (04½mks)

Element	Formula of oxide	Structure
Sodium	Na_2O ✓✗	Giant ionic ✓
Aluminium	Al_2O_3 ✓	Giant ionic ✓
Silicon	SiO_2 ✓✗	Giant molecular ✓
Phosphorous	P_4O_6 ✓ P_4O_{10} ✓	Simple molecular ✓✗

Accept: P_2O_3 P_2O_5

(b) Write equation for the reaction between aluminium oxide and

(i) Dilute hydrochloric acid (01½mks)

$Al_2O_{3(s)} + 6HCl_{(aq)} \longrightarrow 2AlCl_{3(aq)} + 3H_2O_{(l)}$ ✓✓✗

(iii) Excess sodium hydroxide. (01½mks)

$Al_2O_{3(s)} + 6NaOH_{(aq)} + 3H_2O_{(l)} \longrightarrow 2Na_3Al(OH)_{6(aq)}$ ✓✓✗

(c) Write equation of a reaction between the oxide of silicon and sodium hydroxide. (01½mks)

$SiO_{2(s)} + 2NaOH_{(aq)} \longrightarrow Na_2SiO_{3(aq)} + H_2O_{(l)}$ ✓✓✗

Accept: Any other correct equation (alternative) and award accordingly

09mks

END.