EFAS/2118

Model Answers

FEBRUARY 2018 / IN - SEM (T1)
F. Y. B.TECH. (COMMON) (SEMESTER - II)
COURSE NAME: Engineering Chemistry
(2017 PATTERN)

Time: [1 Hour] [Max. Marks : 30]

(*) Instructions to candidates:

1) **Answer Q.1 OR Q.2, Q.3 OR Q.4**
2) **Figures to the right indicate full marks.**
3) **Use of scientific calculator is allowed**
4) **Use suitable data where ever required**

Q.1) a) Solve: [6]

i) **Explain possible combinations of salts that make water alkaline**

Ans: The possible combinations of alkalinities in water are:

i) Only OH^- ii) only CO_3^{-2} iii) Only HCO_3^- iv) OH^- and CO_3^{-2}

v) CO_3^{-2} and HCO_3^-

HCO_3^- and OH^- can not remain together as they react to form CO_3^{-2}

$HCO_3^- + OH^- \rightarrow CO_3^{-2} + H_2O$

ii)100 ml water sample requires 7.6 ml N/50 H_2SO_4 for neutralisation up to phenolphthalein end point and 15.2 ml of the same acid was needed for methyl orange end point. Determine type and amount of alkalinities.

Ans:

V1 = 7.6 ml

V2 = 15.2 ml

P = Phenolphthalein alkalinity $= \frac{V_1 \times Z \times 50 \times 1000}{V}$ ppm $CaCO_3$ equivalent.

$= \frac{7.6 \times 0.02 \times 50 \times 1000}{100} = 76\ ppm$

M = Methyl orange alkalinity = Total alkalinity $= \frac{V_2 \times Z \times 50 \times 1000}{V}$ ppm CaCO3 equivalent

$= \frac{15.2 \times 0.02 \times 50 \times 1000}{100} = 152\ ppm$

As P == ½ M, the type of alkalinity present is only carbonate alkalinity = 2P or M

Therefore, carbonate alkalinity = 152 ppm

b) Compare zeolite and ion exchange process (Give 6 points of comparison). [6]

Ans:

Sr.No.	Zeolite Process	Ion-exchange process
1	Softener used in the process is zeolite crystals.	Softener used in ionexchange process is (synthetic resin) ion exchange resin.
2	Zeolite crystals can exchange sodium ions with multivalent cations present in water	Synthetic resins exchange either their cation or anion for impurities present in water.

3	On treatment with zeolite crystals, soft water obtained contains sodium salt.	On treatment with cation exchanger resin and anion exchanger resin, soft water obtained is free from mineral salts.
4	Zeolite process cannot be used for water containing iron, manganese salts and highly acidic or alkaline water.	Ion exchange process can be used for all types of water sample.
5	Exhausted zeolite can be regenerated by NaCl solution.	Exhausted resins can be regenerated, cation exchange resin using dilHCl and anion exchange resin using dil KOH.
6	Soft water has hardness 5-10 ppm.	Soft water has hardness 0 – 2 ppm

c) Compare scales and sludges (Give 4 points of comparison) [4]

Ans: (any 4)

Sr. No.	Sludge	Scale
1	Sludges are loose slimy precipitates	Scales are hard and adherent precipitates.
2	Sludges are formed by the salts which are less soluble in cold water but soluble in hot water.	Scales are formed by salts which are less soluble in hot water but may be soluble in cold water
3	Sludges are formed at cooler parts of the boiler.	Scales are formed at hot parts or regions of the boiler
4	Sludges are formed due to increase in concentration of the salt. For e.g. $MgCO_3$, $MgCl_2$, $CaCl_2$.	Scales are formed due to decomposition of bicarbonates, hydrolysis of Mg-salts, less solubility in hot water shown by $CaSO_4$, presence of silica.
5	They can be removed by blow-down operation	They can be removed by EDTA treatment

OR

Q.2) a) Solve [6]

i)What is zeolite? Give principle involved in zeolite treatment with exchange reactions.

Ans:

zeolite is hydrated sodium alumino silicate

$Na_2O.Al_2O_3.xSiO_2.yH_2O$ where x = 2 to 10 and y = 2 to 6

Principle: zeolite is hydrated sodium alumino silicate, capable of exchanging reversibly their sodium ions for multivalent cations present in water. Therefore, zeolites find application in softening of water.

ii) Zeolite softener was completely exhausted and was regenerated by passing 90 lit. of NaCl solution containing 1200 mg/lit NaCl. How many litres of sample water of hardness 150 ppm can be softened by this softener?

Solution:

Given 1 lit. ofNaCl solution contains → 1200 mgNaCl

∴ 90 lit. ofNaCl solution contains → 90 × 1200 mg

→ 108,000 mgNaCl

Given, 1 litre water sample contains 150 mg $CaCO_3$ equivalent hardness

∴ Quantity of NaCl required for regeneration of zeolite softner in terms of $CaCO_3$ equivalent

$\frac{50}{58.5} \times 108000$ mg = 92307.69

[Quantity of NaCl required for regeneration in terms of CaCO3 equivalent = Total hardness]

∴ 150 mg CaCO3 equivalent hardness → present in 1 lit of water

∴ 92307.69 mg hardness → ?

$\frac{92307.69}{150}$ litre of water

= 615.38 lit

∴ Quantity of water sample softened = 615.38 lit.

b) Explain determination of total hardness of water by EDTA method. Draw metal EDTA complex. Give chemical reactions involved during titration. **[6]**

Ans: Determination of total hardness of water

Titration part I : Standardisation of EDTA solution:

i) Prepare standard solution of $ZnSO_4$.

ii) Fill a burette with disodium EDTA solution and pipette out 5 ml standard $ZnSO_4$ solution in a conical flask.

iii) Add about 3 ml buffer solution of pH about 10 and 2-3 drops of EBT indicator in it.

iv) Titrate the wine-red coloured mixture against the EDTAsolution till it changes to sky blue.

v) Let the titration reading be V_1 ml.

Calculations:

Standardisation of EDTA:

Let the molarity of ZnSO4 solution prepared be M2 molar. Calculate the molarity of disodium EDTA using volume of ZnSO4 solution pipetted for titration and volume of disodium EDTA (burette reading) by formula,

$$M_1V_1 = M_2V_2$$
$$EDTA = ZnSO_4$$

M1 = Exact molarity of EDTA = ?

Titration part II: Total hardness of water sample:

i) Take 5 ml of the water sample in a conical flask.

ii) Add about 3 ml of the buffer solution of pH 10 and 2-3 drops of EBT indicator solution in it.

iii) Titrate this wine-red mixture against the EDTA solution till the colour changes to **blue**. Let the titration reading be 'y' ml.

Calculation:Determination of Total hardness of water sample:

In general,

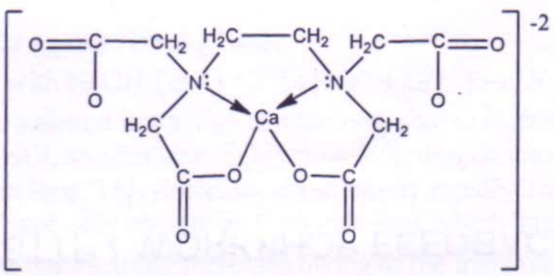
$$\textit{Total hardness of water sample} = \frac{y}{V} X\ Z\ X\ 100\ X\ 1000\ ppm\ CaCO3\ equivalent$$

V = volume of water sample titrated

y = volume of disodium EDTA (burette reading)

Z = molarity of disodium EDTA solution.

Structure of M-EDTA complex:



Reactions:

$$i)\ M + EBT \rightarrow \underset{wine\ red}{M - EBT}$$

$$ii)\ M + EDTA \xrightarrow{pH\ 10} \underset{Colourless}{M - EDTA}$$

$$iii)\ \underset{Wine\ red}{M - EBT} + \underset{Colourless}{EDTA} \rightarrow \underset{Colourless}{M - EDTA} + \underset{Blue}{EBT}$$

c) Explain how dissolved gases cause boiler corrosion. Explain methods to minimize boiler corrosion due to dissolved gases. **[4]**

Ans:

a) Dissolved oxygen:

Dissolved oxygen is the main corrosion causing impurity in water. Dissolved oxygen in water at high temperature attacks boiler metal.

$$2Fe + H_2O + \frac{1}{2}O_2 \xrightarrow{heat} 2\,Fe\,(OH)_2 \xrightarrow{\frac{1}{2}O_2} \underset{rust}{(Fe_2O_3.2H_2O)}$$

Prevention:

Dissolved oxygen can be removed by adding calculated quantity of sodium sulphite (Na_2SO_3) or sodium hydrazine (N_2H_4) or by mechanical de-aeration.

$2\,Na_2SO_3 + O_2 \rightarrow 2\,Na_2\,SO_4$

$Na_2S + 2\,O_2 \rightarrow Na_2SO_4$

$N_2H_4 + O_2 \rightarrow N_2 \uparrow + 2H_2O$

Hydrazine reagent is preferred as it does not release any salt in the water.

b) Dissolved carbon dioxide:

Dissolved carbon dioxide (CO_2) in water forms carbonic acid.

$CO_2 + H_2O \rightarrow H_2CO_3$

Carbonic acid is a weak acid, has a slow corrosive effect on boiler metal.

Carbon dioxide is also released inside the boiler if water contains bicarbonates

$Mg(HCO_3)_2 \xrightarrow{Boiling} Mg\,(OH)_2 \downarrow + 2\,CO_2\uparrow$

Prevention:

Dissolved carbon dioxide may be removed by adding calculated amount of liquid ammonia (NH_4OH) or by de-aeration.

$2\,NH_4OH + CO_2 \rightarrow (NH_4)_2CO_3 + H_2O$

Q.3) a) Explain titration curve for conductometric titration in case of **[6]**

i)strong acid verses strong base

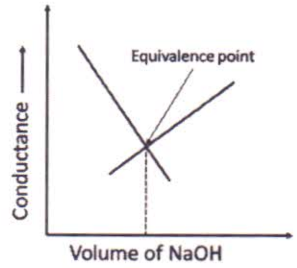
ii)strong base verses weak acid

Ans:

i) Titration of strong acid against strong base:

Consider titration of HCl with NaOH. $[H^+ + Cl^-] + [Na^+ + OH^-] \rightarrow [Na^+ + Cl^-] + H_2O$

At the beginning, the acid solution has a high conductivity due to high mobility of hydrogen ions. When NaOH is added to HCl, smaller size highly mobile hydrogen ions are replaced by comparatively bigger, less mobile sodium ions. This decreases conductivity rapidly.The solution at neutralization i.e. at equivalence point will have only sodium and chloride ions which have minimum conductivity.If more NaOH is added, then conductivity increases owing to the increase in conductivity of OH^- ions. A graph of conductivity is plotted against volume of sodium hydroxide. The point of intersection of two lines gives equivalence point.

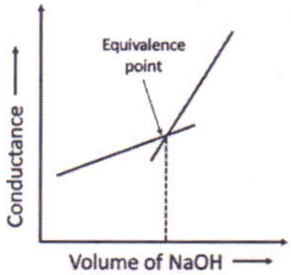


ii) Titration of weak acid against strong base:

Consider titration of CH_3COOH (weak acid) with $NaOH$ (strong base)

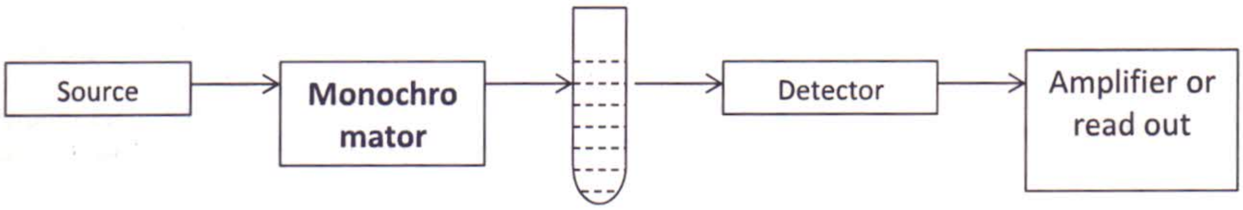
$$[CH_3COO^- + H^+] + [Na^+ + OH^-] \rightarrow [CH_3COO^- + Na^+] + H_2O$$

Acetic acid is taken in beaker and sodium hydroxide is taken in burette. Initial conductivity is less because acetic acid is a weak acid and dissociates less into its ions. After addition of NaOH from burette, conductivity increases due to formation of salt which dissociates more into its ions. When neutralization of acid is complete, further addition of NaOH produce excess of OH^- ions causing rapid increase of conductance.

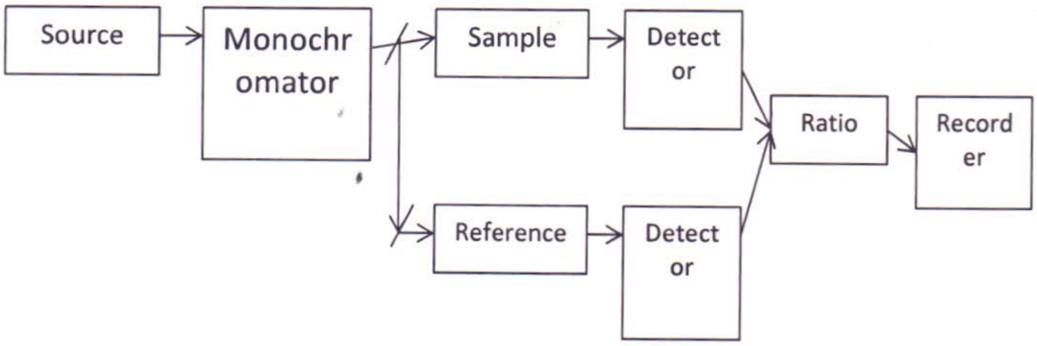


b) Draw block diagram of single beam and double beam spectrometer. Give 4 applications of UV – visible spectrometer **[4]**

i) Single beam spectrophotometer



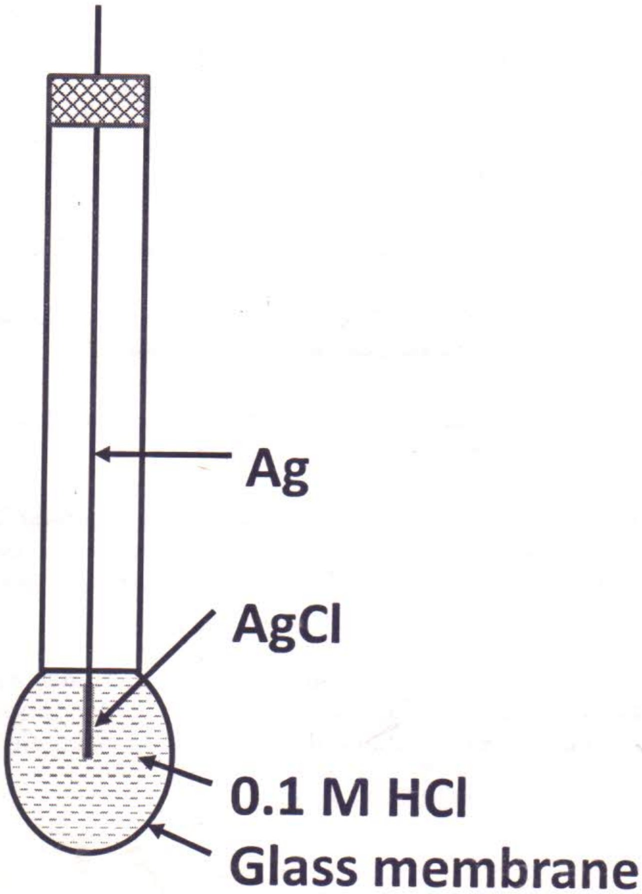
ii) Double beam spectrophotometer



Applications of UV Visible spectroscopy: (Any four)

i) It is useful in identifying chemical substances by comparing spectra of unknown samples with that of standard substance
ii) It is useful in determining very low concentration of solutions which cannot be determined by volumetric or gravimetric method
iii) It is used in detection of impurities
iv) It is useful in studying kinetics of the reactions by following change in concentration of reactants and product with time during reaction
v) UV spectroscopy can be used in determination of Ca in blood and ozone in environment

c) Draw glass electrode. Give its representation. Give 2 advantages and 2 disadvantages of glass electrode. **[4]**
Ans:



Glass electrode representation: Glass electrode is represented as

Pt | 0.1 N HCl | Glass | H+ (Test solution) or

Ag, AgCl | 0.1 N HCl | Glass | H+ (Test solution)

Advantages of glass electrode: (any 2)

i) It may be used in presence of strong oxidizing and reducing solutions.
ii) It can be used for solutions having pH 2 to 10.
iii)It is simple to operate
iv) It can detect and estimate H^+ ions in presence of other types of ions

Disadvantages of glass electrode: (any 2)

i) The glass bulb is very fragile and has to be used with greatcare.
ii) As glass membrane has a high electrical resistance, ordinary potentiometer can not be used, electronic potentiometer are used
iii) it can not be used for solutions of fluoride ions

OR

Q.4) a) Explain different types of electronic transitions with example that occur in organic molecules after absorbing UV – Visible radiation **[6]**

Ans:

When energy is absorbed by a molecule in UV Visible region, it brings changes in electronic energy of molecule because of transition of valence electrons.

3 types of electrons are involved in organic molecule:

i) **σ electrons**: electrons forming single bonds are called σ electrons. These are involved in forming bonds in saturated hydrocarbon such as C-H bonds

ii) **π electrons**: electrons involved in forming double bonds are called as π electrons. These are involved in forming bonds in unsaturated hydrocarbon.

iii) **η electrons**: these are non bonded or lone pair of electrons and are not involved in bonding between atoms in molecules

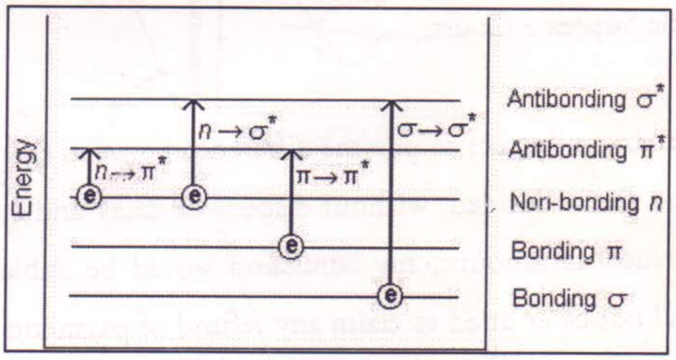
When energy is absorbed in UV Visible region, **possible electronic transitions** are:
$\sigma \longrightarrow \sigma^*, \sigma \longrightarrow \pi^*, \pi \longrightarrow \sigma^*, \pi \longrightarrow \pi^*, \eta \longrightarrow \sigma^*, \eta \longrightarrow \pi^*$
Out of these, $\sigma \longrightarrow \pi^*, \pi \longrightarrow \sigma^*$ are considered as **forbidden** transitions.

i) **$\sigma \rightarrow \sigma^*$:** These transitions are observed in saturated hydrocarbons. Energy required for these transitions is very large. Absorption band occur in the far UV region (126-135nm).For e.g. methane has λ_{max} at 121.9nm, ethane at 135 nm.

ii) **$\pi \longrightarrow \pi^*$:** These transitions are involved in transition of electrons from bonding π to antibonding π* orbital. These transitions occur in molecules having π electron system such as alkenes and alkynes. For e.g. ethylene shows intense band at 174nm and weak band at200nm due to π to π* transition. λ_{max} value increases with increase in conjugation.

iii) **$\eta \longrightarrow \sigma^*$:** Saturated hydrocarbons with lone pair of electrons/non bonding electrons undergoes these transitions. The energy required is less than that of σ to σ* transitions. Corresponding absorption bands appear near UV region(180-200nm)For e.g. aliphatic alcohols, alkyl halides show such transitions.

iv) **$\eta \longrightarrow \pi^*$:** These type of transitions are shown by unsaturated molecules which contain atoms such as oxygen, sulphur, nitrogen. Absorption band of aldehydes and ketones usually occur in the range of 270-300nm.



b) Calculate potential of a redox electrode developed when 100 ml of 0.1N Fe^{+2} solution is titrated with **[4]**
i)20 ml of 0.1 N Ce^{+4} solution
ii) 100 ml of 0.1 N Ce^{+4}solution
Ans:
Volume at equivalence point = 100 ml

i) 20 ml = Before equivalence point volume

$$E = 0.75 + 0.0591\ log\frac{Fe^{+3}}{Fe^{+2}}$$

$$E = 0.75 + 0.0591\ log\frac{2}{8} = 0.71\ V$$

ii) 100 ml = At equivalence point

$$E_0 = \frac{E_1^0 + E_2^0}{2} = \frac{0.75 + 1.45}{2} = \mathbf{1.1}\, V$$

c) Define specific conductance. Explain titration curve for conductometric titration in case of weak base verses strong acid **[4]**

Ans:

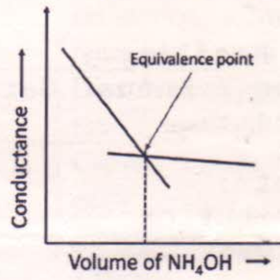
Specific conductance (κ):*It is defined as the conductivity offered by a solution of length 1 cm and area 1 sq.cm. cross section.* It is expressed in $mhos/cm$ or $ohm^{-1}cm^{-1}$

Titration of strong acid against weak base:

Consider titration of HCl (strong acid) with NH_4OH (weak base).

$[H^+Cl^-]+[NH_4^+OH^-] \rightarrow [NH_4^+Cl^-]+[H_2O]$

HCl is taken in beaker and NH_4OH is added from burette. Initial conductivity of solution is high because of strong acid HCl dissociates completely into ions. As ammonium hydroxide is added from burette, conductivity decreases because of replacement of fast moving H^+ ions with slow moving NH_4^+ ions. Addition of NH_4OH after end point, does not change conductance much as NH_4OH is weak electrolyte and has a very small conductivity as compared to its salt.



Marking Scheme: (T1 Engineering Chemistry Sem II 17-18)

Question No.		Difficulty level	Cognitive levels	Marking Scheme
Q.1)	a)	M	Application	i)Types of salts – 2 marks ii)carbonate alkalinity = 152 ppm
	b)	M	Comprehension	6 points – 6 marks
	c)	M	Comprehension	4 points – 4 marks
Q.2)	a)	M	Application	i)Zeolite – 1 mark, principle with reactions – 2 marks ii) Quantity of water= 615.38 litres – 3marks
	b)	M	Comprehension	Determination of total hardness – 4 marks (procedure- standardization and estimation – 2 marks , calculations- standardization and estimation- – 2marks),structure – 1mark, reactions 1 mark
	c)	M	Comprehension	Dissolved oxygen and carbon dioxide – 2 marks, methods of minimizing – 2 marks
Q.3)	a)	M	Comprehension	Curve – 1 marks each, explanation – 2 marks each
	b)	M	Comprehension	2 block diagrams – 2 marks, 4 applications – 2marks
	c)	L	Comprehension	Glass electrode- figure – 1 mark, representation – 1 mark advantages – 1 mark, disadvantages.- 1mark
Q.4)	a)	M	Comprehension	Possible transitions – 1 mark, figure – 1 mark, 4 transitions with example -4 marks
	b)	M	Application	i)E = 0.71V – 2 marks ii)E = 1.1 V – 2 marks
	c)	M	Comprehension	Definition – 1 mark, titration curve – 1 mark, explanation – 2 marks