# VISVESVARAYA TECHNOLOGICAL UNIVERSITY
## BELAGAVI

# ENGINEERING CHEMISTRY FORMULA HANDBOOK

### I and II Semester BE Program (For Scheme 2025)

Basic Science and Humanities Composite Board

VISVESVARAYA
TECHNOLOGICAL UNIVERSITY
BELAGAVI

Jnana Sangama, VTU Main Road, Machhe,
Belagavi, Karnataka - 590018

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY**
**BELAGAVI**

# CHEMISTRY

## HAND BOOK

## FOR CSE/EEE/ME/CIVIL STREAMS

### I / II Semester BE Program

**Effective From The Academic Year**
**2026**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
# ENGINEERING CHEMISTRY HANDBOOK

**REGISTRAR**
Visvesvaraya Technological University
"Jnana Sangama", BELAGAVI-590 018.

**MRP Rs. : 40.00/-**

**1. Seven basics S.I. units:**

| *Length* | Mass | Time | Temperature | Electric Current | Luminous Intensity | Amount of substance |
|---|---|---|---|---|---|---|
| metre ($m$) | Kilogram ($kg$) | Second ($s$) | Kelvin ($K$) | Ampere ($A$) | Candela ($Cd$) | Mole ($mol$) |

**2. Derived Units:**

| Physical quantity | Unit | Symbol |
|---|---|---|
| Area | square metre | $m^2$ |
| Volume | cubic metre | $m^3$ |
| Velocity | metre per second | $ms^{-1}$ |
| Acceleration | metre per second square | $ms^{-2}$ |
| Density | kilogram per cubic metre | $kg\ m^{-3}$ |
| Molar mass | kilogram per mole | $kg\ mol^{-1}$ |
| Molar volume | cubic metre per mole | $m^3\ mol^{-1}$ |
| Molar concentration | mole per cubic metre | $mol\ m^{-3}$ |
| Force | newton ($N$) | $kg\ m\ s^{-2}$ |
| Pressure | pascal ($Pa$) | $N\ m^{-2}$ |
| Energy work | joule ($J$) | $kg\ m^2\ s^{-2}$, $Nm$ |

**3. Conversion factors:**

| | | | |
|---|---|---|---|
| 1 m = 39.37 inch | 1 cal = 4.184 J | 1 e.s.u. = $3.3356 \times 10^{-10}$ C | 1 mole of a gas = 22.4 L at STP |
| 1 inch = 2.54 cm | 1 eV = $1.602 \times 10^{-19}$ J | 1 dyne = $10^{-5}$ N | 1 mole a substance = $N_0$ molecules |
| 1 litre = 1000 mL | 1 eV/atom =96.5 kJ $mol^{-1}$ | 1 atm = 101325 Pa | 1 g atom = $N_0$ atoms |
| 1 gallon (US) = 3.79 L | 1 amu = 931.5016 MeV | 1 bar = $1 \times 10^5$ N $m^{-2}$ | t (°F) = 9/5 t (°C) + 32 |
| 1 lb = 453.59237 g | 1 kilo watt hour = 3600 kJ | 1 litre atm = 101.3 J | 1 g $cm^{-3}$ = 1000 kg $m^{-3}$ |
| 1 newton =1 kg m $s^{-2}$ | 1 horse power = 746 watt | 1 year = $3.1536 \times 10^7$ s | 1Å = $10^{-10}$ m |
| 1 J = 1 Nm =1 kg $m^2$ $s^{-2}$ | 1 joule = $10^7$ erg | 1 debye (D) = $1 \times 10^{-18}$ esu cm | 1nm = $10^{-9}$ m |

**4. Standard prefixes are used to reduce the basic units:**

| Multiple | Prefix | Symbol | Submultiple | Prefix | Symbol |
|---|---|---|---|---|---|
| $10^{24}$ | yotta | Y | $10^{-1}$ | deci | d |
| $10^{21}$ | zetta | Z | $10^{-2}$ | centi | c |

| | | | | | |
|---|---|---|---|---|---|
| $10^{18}$ | exa | E | $10^{-3}$ | milli | m |
| $10^{15}$ | peta | P | $10^{-6}$ | micro | μ |
| $10^{12}$ | tera | T | $10^{-9}$ | nano | n |
| $10^{9}$ | giga | G | $10^{-12}$ | pico | p |
| $10^{6}$ | mega | M | $10^{-15}$ | femto | f |
| $10^{3}$ | kilo | k | $10^{-18}$ | atto | a |
| $10^{2}$ | hecto | h | $10^{-21}$ | zeto | z |
| $10^{1}$ | deca | da | $10^{-24}$ | yocto | y |

**5. Galvanic Series:**

<table>
<tr><td>Mg</td><td rowspan="14">Base metals</td></tr>
<tr><td>Mg alloys</td></tr>
<tr><td>ZN</td></tr>
<tr><td>Al</td></tr>
<tr><td>Cd</td></tr>
<tr><td>Al alloys</td></tr>
<tr><td>Mild steel</td></tr>
<tr><td>Cast steel</td></tr>
<tr><td>Pb</td></tr>
<tr><td>Sn</td></tr>
<tr><td>Brass</td></tr>
<tr><td>Cu</td></tr>
<tr><td>Ni</td></tr>
<tr><td>Stainless steel (18% Cr & 8% Ni)</td></tr>
<tr><td>Ag</td><td rowspan="4">Noble metals</td></tr>
<tr><td>Ti</td></tr>
<tr><td>Au</td></tr>
<tr><td>PT</td></tr>
</table>

**6. Beer-Lamberts law:** The Beer-Lambert law states that the absorbance of a solution is directly proportional to the concentration of the absorbing substance and the path length the light travels through the solution.

$$A = \varepsilon c l$$

A – Absorbance
ε – Molar absorption co-efficient ($M^{-1}cm^{-1}$)
C – Molar concentration (M)
l – optical path length (cm)

**7. Oxidation-Reduction Titrations:**

$$\text{Oxidation form} + n\,e^- \rightleftharpoons \text{Reduced form}$$

$$E_{\text{Cell}} = E^0 + \frac{0.0591}{n}\log\frac{a_{oxidised\ form}}{a_{reduced\ form}}$$

$$K_2Cr_2O_7 + 6FeSO_4 + 7H_2SO_4 \longrightarrow 2Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + K_2SO_4 + 7H_2O$$

**8. Ohm's Law:**

Ohm's law in electrochemistry applies to the relationship between voltage (V), current (I), and resistance (R) in an electrolyte solution.

$$I = \frac{V}{R}.$$

**9. Equivalent Conductance ($\Lambda$):** Equivalent conductance is a measure of an electrolyte's conducting ability in a solution, specifically the conductance of all ions produced from one gram-equivalent of the electrolytes.

$$\Lambda = \frac{\kappa}{M}$$

If **M** is in the units of molarity *i.e.*, moles per litre ($mol\ L^{-1}$),

The $\Lambda$ may be expressed as, $\Lambda = \frac{\kappa \times 1000}{M}$

**10. Speccific Conductance ($\Omega^{-1}m^{-1}$):**

$$\kappa = \frac{1}{R}\ x\ \frac{L}{A}$$

κ - specific conductance
R - the resistance of the solution in Ohms
L - the distance between the electrodes (in meters, m, or cm)
A - the cross-sectional area of the electrodes (in square meters or square centimeters)

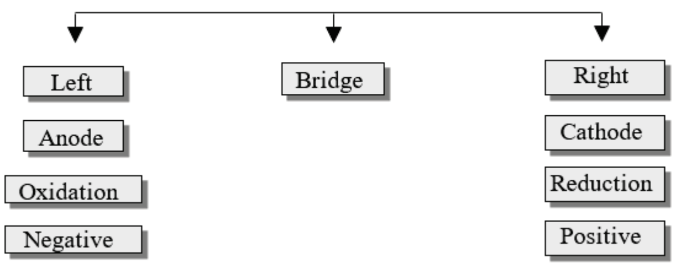
**11. Strong acid Vs Strong base:**

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

**12. Weak acid Vs Strong base:**

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

**13. Galvanic cell:**




**14. Cell EMF and the spontaneity of the reaction:**

| Nature of reaction | $\Delta G$(or $\Delta G^o$) | $E_{cell}$ (or $E^o_{cell}$) |
|---|---|---|

| | | |
|---|---|---|
| Spontaneous | – | + |
| Equilibrium | 0 | 0 |
| Non – spontaneous | + | – |

**15. Nernst equation for single electrode:**

$$E = E^0 - \frac{RT}{nF} \ln Q$$

Here E is the electrode potential, $E^o$ is the standard electrode potential, R is the ideal gas constant, T is the temperature in Kelvin, n is the number of electrons transferred, F is the Faraday constant, and Q is the reaction quotient. This equation relates the potential of an electrode under non-standard conditions to its standard potential.

**16.**

$$E_{\text{Cell}} = E^o + \frac{0.0591}{2}\log C_2 - (E^o + \frac{0.0591}{2}\log C_1)$$

$$E_{\text{Cell}} = \frac{0.0591}{2}\log \frac{C_2}{C_1}$$

**17. Nernst Equation:**

$$E = E^0 + \frac{0.0591}{n}\log_{10}[\mathrm{M^{n+}}]$$

Where, $n = no\ of\ electrons$

**18. Concentration cell:**

$$E = \frac{0.0591}{n}\log_{10}\frac{[\text{cathode}]}{[\text{anode}]}$$

Where, $n = no\ of\ electrons$

**19. Glass Electrode:**

$$E = \frac{E_G^0 - E_{cell} - E_{SCE}}{0.0591}$$

**20. Molecular mass:**

$$\text{Molecular mass} = \frac{\text{Mass of one molecule of the substance}}{\frac{1}{12}\text{ x Mass of one atom of C} - 12}$$

**21. Types of Electrodes**

a) Cu|CuSO4,Zn|ZnSO4

b) Hydrogen Electrode

c) $Hg|Hg_2Cl_2|Cl^-$

d) Glass electrode

e) $Pb\text{-}Hg/Pb^{2+}$

**22. Cell EMF and the spontaneity of the reaction:**

| Nature of reaction | $\Delta G$(or $\Delta G^o$) | $E_{cell}$ (or $E^o_{cell}$) |
|---|---|---|
| Spontaneous | – | + |

| | | |
|---|---|---|
| Equilibrium | 0 | 0 |
| Non – spontaneous | + | – |

**23. Various types of Half cells:**

| Type | Example | Half – cell reaction | *Q* = | Reversible to | Electrode Potential (oxid$^n$), *E* = |
|---|---|---|---|---|---|
| Gas ion half - cell | $Pt(H_2)\vert\ H^+(aq)$<br>$Pt(Cl_2)\vert\ Cl^-(aq)$ | $\frac{1}{2}H_2(g) \rightarrow H^+(aq) + e^-$<br>$Cl^-(aq) \rightarrow \frac{1}{2}Cl_2(g) + e^-$ | $[H^+]$<br>$\frac{1}{[Cl^-]}$ | $H^+$<br>$Cl^-$ | $E^0 - 0.0591\ \log[H^+]$<br>$E^0 + 0.0591\ \log[Cl^-]$ |
| Metal – metal ion half – cell | $Ag\vert\ Ag^+(aq)$ | $Ag(s) \rightarrow Ag^+(aq) + e^-$ | $[Ag^+]$ | $Ag^+$ | $E^0 - 0.0591\ \log[Ag^+]$ |
| Metal insoluble salt anion half – cell | $Ag, AgCl\vert\ Cl^-(aq)$ | $Ag(s) + Cl^-(aq) \rightarrow AgCl(s) + e^-$ | $\frac{1}{[Cl^-]}$ | $Cl^-$ | $E^0 + 0.0591\ \log[Cl^-]$ |
| Calomel electrode | $Hg, Hg_2Cl_2\vert\ Cl^-(aq)$ | $2Hg(l) + 2Cl^-(aq) \rightarrow$<br>$Hg_2Cl_2(s) + 2e^-$ | $\frac{1}{[Cl^-]^2}$ | $Cl^-$ | $E^0 + 0.0591\ \log[Cl^-]$ |
| Metal – metal oxide hydroxide half - cell | $Hg, HgO\vert\ OH^-(aq)$ | $Hg(l) + 2OH^-(aq) \rightarrow$<br>$HgO(s) + H_2O(l) + 2e^-$ | $\frac{1}{[OH^-]^2}$ | $OH^-$ | $E^0 + 0.0591\ \log[OH^-]$ |
| Oxidation – reduction half – dell | $Pt\vert\ Fe^{2+}_{(aq)}, Fe^{3+}_{(aq)}$ | $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$ | $\frac{[Fe^{3+}]}{[Fe^{2+}]}$ | $Fe^{2+}, Fe^{3+}$ | $E^0 - 0.0591\ \log\frac{[Fe^{3+}]}{[Fe^{2+}]}$ |

**24. Comparison of mass, charge and specific charge of electron, proton and neutron:**

| ***Name of constant*** | ***Unit*** | **Electron ($e^-$)** | **Proton ($p^+$)** | **Neutron (n)** |
|---|---|---|---|---|
| Mass ($m$) | Amu<br>*Kg*<br>Relative | 0.000546<br>$9.109 \times 10^{-31}$<br>1/1837 | 1.00728<br>$1.673 \times 10^{-27}$<br>1 | 1.00899<br>$1.675 \times 10^{-27}$<br>1 |
| Charge($e$) | Coulomb ($C$)<br>Esu<br>Relative | $-1.602 \times 10^{-19}$<br>$-4.8 \times 10^{-10}$<br>– 1 | $+1.602 \times 10^{-19}$<br>$+4.8 \times 10^{-10}$<br>+1 | Zero<br>Zero<br>Zero |
| Specific charge ($e/m$) | C/g | $1.76 \times 10^8$ | $9.58 \times 10^4$ | Zero |
| Density | Gram / cc | $2.17 \times 10^{-17}$ | $1.114 \times 10^{14}$ | $1.5 \times 10^{-14}$ |

**25. Standard ambient temperature and pressure:**

| Condition | T | P | $V_m$ (Molar volume) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| S.T.P./N.T.P. | 273.15 $K$ | 1 $atm$ | 22.414 $L$ |
| S.A.T.P*. | 298.15 $K$ | 1 $bar$ | 24.800 $L$ |

**26. P<sup>H</sup> Scale:**

| | $[H^+]$ | $[OH^-]$ | $pH$ | $pOH$ |
|---|---|---|---|---|
| **Acidic solution** | $> 10^{-7}$ | $< 10^{-7}$ | $< 7$ | $> 7$ |
| **Neutral solution** | $10^{-7}$ | $10^{-7}$ | 7 | 7 |
| **Basic solution** | $< 10^{-7}$ | $> 10^{-7}$ | $> 7$ | $< 7$ |

**27. Equivalent weight of few oxidizing/reducing agents:**

| Agents | O. N. | Product | O. N. | Change in O. N. per atom | Total Change in O. N. per mole | Eq. wt. |
|---|---|---|---|---|---|---|
| $Cr_2O_7^{2-}$ | + 6 | $Cr^{3+}$ | + 3 | 3 | 3 × 2 = 6 | Mol. wt./6 |
| $C_2O_4^{2-}$ | + 3 | $CO_2$ | + 4 | 1 | 1 × 2 = 2 | Mol. wt./2 |
| $S_2O_3^{2-}$ | + 2 | $S_4O_6^{2-}$ | + 2.5 | 0.5 | 0.5 × 2 = 1 | Mol. wt./1 |
| $H_2O_2$ | – 1 | $H_2O$ | – 2 | 1 | 1 × 2 = 2 | Mol. wt./2 |
| $H_2O_2$ | – 1 | $O_2$ | 0 | 1 | 1 × 2 = 2 | Mol. wt./2 |
| $MnO_4^-$ (Acidic medium) | + 7 | $Mn^{2+}$ | + 2 | 5 | 5 × 1 = 5 | Mol. wt./5 |
| $MnO_4^-$ (Neutral medium) | + 7 | $MnO_2$ | + 4 | 3 | 3 × 1 = 3 | Mol. wt./3 |
| $MnO_4^-$ (Alkaline medium) | + 7 | $MnO_4^{2-}$ | + 6 | 1 | 1 × 1 = 1 | Mol. wt./1 |

**28. Products of electrolysis of some electrolytes:**

| Electrolyte | Electrode | Product at cathode | Product at anode |
|---|---|---|---|
| Aqueous $NaOH$ | $Pt$ or Graphite | $2H^+ + 2e^- \rightarrow H_2$ | $2OH^- \rightarrow \frac{1}{2}O_2 + H_2O + 2e^-$ |
| Fused $NaOH$ | $Pt$ or Graphite | $Na^+ + e^- \rightarrow Na$ | $2OH^- \rightarrow \frac{1}{2}O_2 + H_2O + 2e^-$ |
| Aqueous $NaCl$ | $Pt$ or Graphite | $2H^+ + 2e^- \rightarrow H_2$ | $2Cl^- \rightarrow Cl_2 + 2e^-$ |
| Fused $NaCl$ | $Pt$ or Graphite | $Na^+ + e^- \rightarrow Na$ | $2Cl^- \rightarrow Cl_2 + 2e^-$ |
| Aqueous $CuSO_4$ | $Pt$ or Graphite | $Cu^{2+} + 2e^- \rightarrow Cu$ | $2OH^- \rightarrow \frac{1}{2}O_2 + H_2O + 2e^-$ |
| Aqueous $CuSO_4$ | $Cu$ electrode | $Cu^{2+} + 2e^- \rightarrow Cu$ | $Cu$ oxidised to $Cu^{2+}$ ions |
| Dilute $H_2SO_4$ | $Pt$ electrode | $2H^+ + 2e^- \rightarrow H_2$ | $2OH^- \rightarrow \frac{1}{2}O_2 + H_2O + 2e^-$ |
| Conc. $H_2SO_4$ | $Pt$ electrode | $2H^+ + 2e^- \rightarrow H_2$ | Peroxodisulphuric acid $(H_2S_2O_8)$ |

| | | | |
|---|---|---|---|
| Aqueous $AgNO_3$ | $Pt$ electrode | $Ag^{+} + e^{-} \rightarrow Ag$ | $2OH^{-} \rightarrow \frac{1}{2}O_2 + H_2O + 2e^{-}$ |
| Aqueous $AgNO_3$ | $Ag$ electrode | $Ag^{+} + e^{-} \rightarrow Ag$ | $Ag$ oxidised to $Ag^{+}$ ions |

**29. pH and pOH:**

In electrochemistry, pH is a crucial measure of acidity or alkalinity that directly impacts electrochemical reactions by influencing the concentration of hydrogen ions.

Formula $pH = -\log [H^{+}]$

In electrochemistry, pOH is a measure of the hydroxide ion ($OH^-$) concentration, calculated as the negative logarithm of the hydroxide ion concentration,

pOH= -log [$OH^-$]

Relation $pH + pOH = 14$

Ionic Product of Water $K_w = [H^{+}][OH^{-}] = 10^{-14}$

**30. pH of some materials;**

| **Material** | ***pH*** | **Material** | ***pH*** |
|---|---|---|---|
| Gastric juice | 1.4 | Rain water | 6.5 |
| Lemon juice | 2.1 | Pure water | 7.0 |
| Vinegar | 2.9 | Human saliva | 7.0 |
| Soft drinks | 3.0 | Blood plasma | 7.4 |
| Beer | 4.5 | Tears | 7.4 |
| Black coffee | 5.0 | Egg | 7.8 |
| Cow's milk | 6.5 | Household ammonia | 11.9 |

**31. Normality:** Normality (N) is defined as the number of gram equivalents of solute present in one litre of solution. In SI, its unit is equivalents/litre (eq/L or N).

N=$[= x \times \text{No. of millimoles}]$

$$= x \times \text{Molarity} = \frac{\text{Strength in } gm\ litre^{-1}}{\text{Eq. wt.}}$$

**32. Normality formula**, $N_1V_1 = N_2V_2$

**33. Thermodynamics** $E_2 - E_1 = \Delta E = q + w$

**34. Electrochemical series:** The electrochemical series, also known as the activity series, is a list of elements arranged by their standard electrode potentials. This arrangement ranks elements by their tendency to gain or lose electrons, with elements at the top being more reactive and easily oxidized (losing electrons), and those at the bottom being less reactive and more easily reduced (gaining electrons).

| **$M^{n+}$/M** | **$E^0$ (V)** |
|---|---|
| $Li^+$/Li | -3.05 |

| | |
|---|---|
| $Mg^{2+}/Mg$ | -2.37 |
| $Zn^{2+}/Zn$ | -0.76 |
| $Fe^{2+}/Fe$ | -0.44 |
| $Cd^{2+}/Cd$ | -0.40 |
| $M^{n+}/M$ | $E^0$ (V) |
| $H^+/H_2$ | 00 |
| $Cu^{2+}/Cu$ | 0.34 |
| $Ag^+/Ag$ | 0.8 |
| $Pt^{2+}/Pt$ | 1.20 |
| $Au^{3+}/Au$ | 1.38 |

**35. Corrosion Penetration Ratio (CPR):** The corrosion penetration ratio, more commonly known as Corrosion Penetration Rate (CPR), measures how quickly a metal deteriorates due to corrosion, typically expressed in mils per year (mpy) or millimeters per year (mm/y).

$$\mathbf{CPR} = \frac{\mathbf{k \ x \ W}}{\mathbf{D(\rho) \ x \ A \ x \ T}}$$

Where, W- is weight loss after exposure time.
T- is exposure time in corrosive medium.
D- is the density of metal.
A -is surface area of exposed specimen.
K - is constant.

| | | | | |
|---|---|---|---|---|
| 1 mm = 0.0393701 inch | 1 inch = 25.4 mm | | CPR in mpy | CPR in mmpy |
| 1 cm = 0.3937 inches | 1 inch = 2.54 cm | K | 534 | 87.6 |
| 1 sq cm =0.155 sq inches | 1 inch = 0.0254 m | W | mg | Mg |
| 1 meter = 39.37 inches | 1 sq inch = 645.16 $mm^2$ | ρ | $g/cm^3$ | $g/cm^3$ |
| 1 sq meter = 1550 sq inches | 1 sq inch = 6.4516 $cm^2$ | A | $inch^2$ | $cm^2$ |
| 1 foot = 12 inches | 1 sq inch = 0.00064516 $m^2$ | t | hrs | Hrs |

**36. Throwing Power:**

$$\% \ of \ throwing \ power = \frac{100\ (\mathrm{A} - \mathrm{B})}{\mathrm{A} + \mathrm{B} - 2}$$

Where A= $d_1/d_2$ (where $d_1>d_2$) and B= $w_2/w_1$

**37. Gross Calorific value:**

$$\mathrm{GCV} = \frac{(W + w)\ X\ (\Delta t)\ \ \mathrm{X\,s}}{m}\,\mathrm{kJ/Kg}$$

$$NCV = [\frac{(W+w)\ X\ (\Delta t)\ \ \mathrm{X\,s}}{m} - (0.09\ \mathrm{X}\ \%\ \ \mathrm{H_2\ X\ L}\ )]\ \mathrm{kJ/Kg}$$

**38. (i) Number average molecular mass ($\overline{M}_N$):**

$$\overline{M}_N = \frac{N_1M_1 + N_2M_2 + N_3M_3 + \ldots}{N_1 + N_2 + N_3 \ldots}$$

$$\overline{M}_N = \frac{\sum N_iM_i}{\sum N_i}$$

Where $N_i$ is the number of molecules of the *i*th type with molecular mass $M_i$.

**(ii) Weight average molecular mass ($\overline{M}_W$) :**

$$\overline{M}_W = \frac{m_1M_1 + m_2M_2 + m_3M_3 \ldots.}{m_1 + m_2 + m_3 + \ldots} \text{ or } = \frac{\sum m_iM_i}{\sum m_i}$$

But $m_i = N_iM_i$, so that $\overline{M}_W = \dfrac{\sum N_iM_i^2}{\sum N_iM_i}$

*Where* $N_i$ is the number of molecules of mass $M_i$.

**39. Daniel cell:** A Daniel cell is an electrochemical cell that converts chemical energy into electrical energy through a spontaneous redox reaction.

Represented as $Zn_{(s)}|ZnSO_{4(aq)} || CuSO_{4(aq)} | Cu_{(s)}$

Mathematically Emf of a cell represented as,

$$E_{cell} = E_{Right} - E_{Left}$$

$$E_{cell} = E_{Cathode} - E_{anode}$$

**40. Chemical Oxygen Demand (COD):**

COD as mg/l of oxygen consumed =(A-B) x Normality of FAS x 8000 / ml. of sample taken

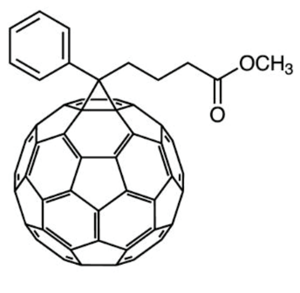
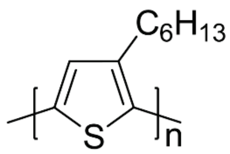
Where A = ml. of FAS used for titration of blank

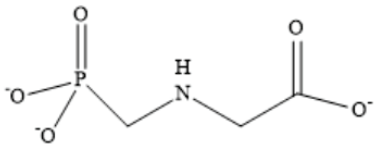
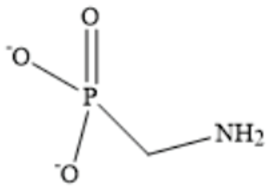
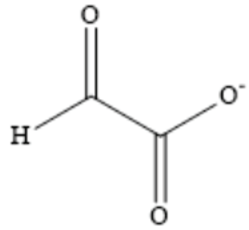
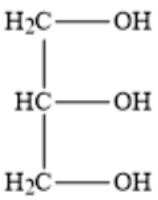
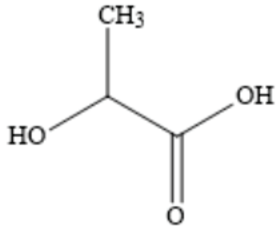
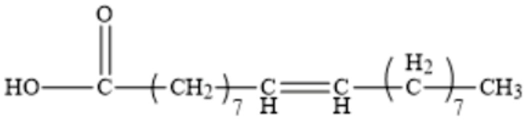
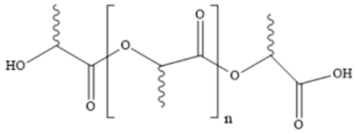
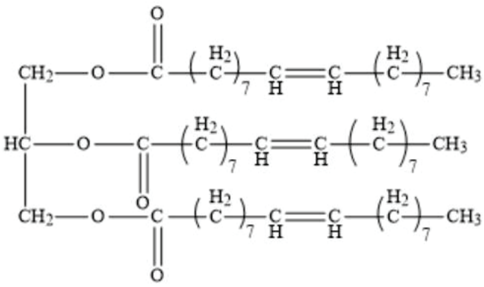
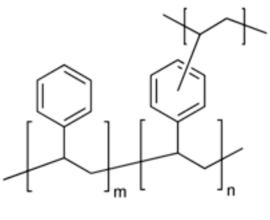
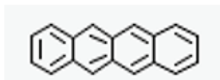
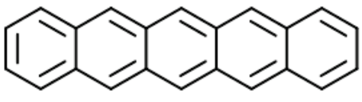
B = ml. of FAS used for titration of sample

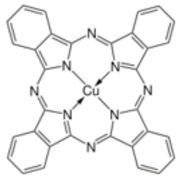
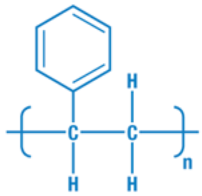
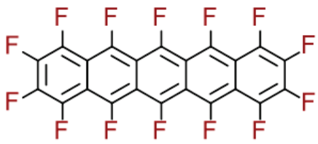
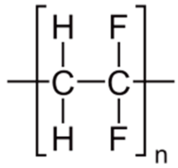
The following formula is used to calculate COD:

$$\text{COD} = \frac{8000(b-s)n}{\text{sample volume}}$$

**41. Structures:**

| | |
|---|---|
|  **Phenyl-C61-butyric acid methyl ester (PCBM)** |  **Poly-3-Hexyl-Thiophene** |

| | |
|---|---|
| <br>**Glyphosate** | $HOOC—(CH_2)_4—COOH$<br>**Adipic Acid** |
| <br>**Amidpomethylphosphonic Acid (AMPA)** | <br>**Glyoxylate** |
|  **Glycerol** |  **Lactic Acid** |
| <br>**Oleic Acid** |  **Polylactic acid** |
| <br>**Glycerol trioleate (Triolein)** | $H_2N—(CH_2)_6—NH_2$<br>**Hexamethylene diamine**<br>Ti-O-Ti<br>**Titanium Oxide Frame** |
|  **Polydivinylbenzene** | <br>**Tetracene**<br> **Pentacene** |

| | |
|---|---|
|  **phthalocyanine** |  **Polystyrene** |
| $Ti(OR)_4$ **Titanium Alkoxide** | such as $Et_3Al/Ti\ (OC_3H_7)_4$ **Ziegler–Natta catalyst** |
|  **Perfluoropentacene** |  **PVDF** |

# Rough Work

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