Chemical engineering / Chemistry

Monday, December 18, 2023 8:19 PM

1. Correlate with environment and science and tech
2. Chemistry = lab, ChemE = industry scale up
3. ChemE
    a. A combination of
        i. Unit operations - physical changes like mass transfer (distillation, adsorption, absorption), heat transfer, fluid mechanics
        ii. Unit processes - chemical changes like halogenation, oxidation
    b. ChemE = branch of engineering concerned with processes in which materials undergo a required change in composition, energy content or physical state, giving products of commercial value
4. Relevant subjects - white ones relevant
    a. Mass transfer operations
    b. Chemical reaction engineering - reactor types like batch, PFR, Mixed flow, semi-batch etc., reaction types like endo-exo, order based, elementary and non-elementary, rev-irrev, homo-heterogenous, difference b/w ideal and non-ideal reactors
    c. Fluid mechanics - pumps
    d. Heat transfer - conduction, convection, radiation, heat exchangers
    e. Thermodynamics favourite - laws, heat engines, entropy
    f. Chemical technology - petroleum industry, fertiliser industry, paper and pulp industry, polymer industry
    g. Process dynamics and control
    h. Mechanical operations
    i. Process calculations
    j. Plant design and economics

5. History of Modern Chemical industry - IR of UK (1800s)

6. Acts related to chemical industry?
    a. Factories Act 1948 - with respect to occupational safety and health in factories
    b. Petroleum Act 1934 - relating to import, transport, storage, production, refining and blending of petroleum
    c. Disaster Management act 2005
    d. Prevent pollution - Water (Prevention and control of pollution) act 1974 - created CPCB
    e. Air (Prevention and Control of Pollution) Act, 1981
    f. Noise Pollution (Regulation and Control) Rules, 2000 notified under EPA 1986

7. CRE - basics
    a. What all does it cover? - Design of reactors based on requirement - continuous or batch process
    b. Why were you fascinated by it? - lies at the core of any plant, my project was also related to this
    c. Reactors
        i. Batch reactor - discharge valve opened for emptying only after reaction complete
        ii. CSTR
            1) Assume perfect mixing, continuous inlet and outlet flow, compositions function of residence time and reaction rate
            2) Challenge - reactant bypass to discharge, non-uniform mixing, needs less reaction time
            3) Major usage in waste treatment plant
        iii. Plug-flow reactor
            1) Continuous tubular reactor, mixing only in radial direction, develops concentration profile
            2) For gas and liquid phase reactions
        iv. Nuclear reactor
            1) Rawatbhata - its capacity, concerns
                a) Capacity - 5 reactors = 1x200 + 4x220 MW

b) Concerns - Tritium leak, meteorite fell nearby

2) 3 stage nuclear programme
   a) Stage 1 - PHWR
      1) 0.7% U-235 with 99.3% U-238
      2) 'Closed cycle' - chemical separation of Pu-239 and U-238
   b) Stage 2 - FBR (500 MW prototype by BHAVINI PSU)
      1) Pu-239 core with U-238 blanket (transmutes to Pu-239)
      2) 2nd blanket of Th-232 around FBR for neutron capture (transmutes to U-233)
   c) Stage 3 - Advanced nuclear power system for Th utilization
      1) U-233 core with Th-232 blanket

8. Hypothetical plant design
   a. Which factors to consider - RM, Land, EIA, labor, market
   b. Estimation

9. Moon and Chemistry
   a. C1 - OH- in polar regions, minerals (Na, Mg, Al, Si), Crater images
   b. C2 - Only orbiter success, Water in polar regions and underground, minerals (Cr, Mn), Sarabhai Crater, Ar-40 in lunar ionosphere
   c. C3
      i. Objectives
         1) to explore far side and land at the South Polar Region of the moon, use same orbiter
         2) Lunar surface related - its thermal properties, lunar-quakes, changes in surface plasma
         3) Possibility of the presence of water in permanently shadowed areas around South Pole
         4) The region has craters that are cold traps (-250 deg C) and contain a fossil record of the early Solar System
         5) The regolith in the region has traces of H2, NH3, CH4, Na, Hg, Ag
   d. ISRO on the moon by 2040 - S Somnath

10. MARKET
    a. 7% contribution to GDP

180 Bn	2021
300 Bn	2027 at 12% CAGR

    b. Producer - 6th world, 3rd Asia BUT Chinese Industry = 8X Indian industry size
    c. Listed ones on BSE SENSEX - Sun Pharma, ONGC, RIL, UltraTech cement
    d. Diversified in India - classified into 6 categories - bulk chemicals (NaOH, Cl2, H2SO4), specialty chemicals, agrochemicals, petrochemicals, polymers and fertilisers
    e. Key challenges
       i. Import dependence on input goods - Oil/Gas, API (68% imported from China), antibiotics (80% components imported from China)
       ii. Quality compliance
          1) highest FDA inspections
          2) Gambia and Uzbekistan children deaths from EG
       iii. Compulsory licensing - deters investments
       iv. Emerging competition like Vietnam, Thailand
       v. Weak product development (R&D)
       vi. Capital and land acquisition
       vii. Need to improve safety track record
       viii. Pollution + water use
    f. India imports lots of organic and inorganic chemicals, Don't India have resources of their own?
       i. $26 Bn imports in 2021 - China alone 12 Bn, US 2 Bn
       ii. Reasons are competitive edge, process efficiency reduced cost over the years
       iii. Steps being taken to reduce import dependence, esp. after Covid
          1) Improved R&D

2) Development of indigenous value chains
3) Revival of bulk chemical plants - methanol, ethanol

g. Recently China continued Anti-dumping duty on some Indian chemicals for 5 more years. What is this duty? Is it allowed by WTO?
   i. A product is considered to be "dumped" if it is exported to another country at a price below the normal price of a like product in the exporting country.
   ii. Anti-dumping measures are unilateral remedies (the imposition of anti-dumping duties on the product in question) that the government of the importing country may apply after a thorough investigation has determined that the product is, in fact, being dumped, and that sales of the dumped product are causing material injury to a domestic industry that produces a like product.
   iii. Anti-Dumping Agreement of WTO
      1) Part of broader General Agreement on Tariffs and Trade 1994
      2) Ensures that WTO members will not apply anti-dumping measures arbitrarily
      3) Provides detailed substantive requirements for determining whether dumping and injury are taking place
      4) Sets forth elaborate procedures for govts to follow when they conduct anti-dumping investigations and impose anti-dumping duties
      5) Ensures that all proceedings will be transparent and that all interested parties have a full opportunity to defend their interests

h. Bright spots in Chemical industry's future
   i. Specialty chemicals
      1) Also called specialties or effect chemicals
      2) Particular chemical products which provide a wide variety of effects on which other industry sectors rely
      3) Cosmetics, dyes and pigments, adhesives, flavors, paints etc.
   ii. Petrochemicals
      1) 4th largest refinery hub in the world after US, China and Russia
      2) 23 refineries - 19 set up by PSU, 1 by a Joint Venture Company, and 3 by Private Companies
   iii. Pharmaceuticals
      1) $ 50 Bn - 2022, ES - $130 Bn by 2030
      2) New 277 bulk drug parks, 13 mfg facilities for medical devices, Penicillin-G to be indigenously manufactured
      3) Patanjali misleading ads - banned under Drugs and Magic Remedies (Objectionable Advertisements) Act, 1954
      4) Product vs process patent
         a) India prior to 2005, recognised process patents, leaving flexibility for drug makers to develop the same drug by minor changes in patented process
         b) TRIPS in WTO ----> India under international pressure amended Patents Act 1970
            1) Allowed product patents ---> now cannot blindly copy product until patent holds
            2) In view of impact on healthcare due to Product patents, Compulsory licensing allowed - only to meet domestic requirement and not for export purposes
            3) Also, maker of generics can apply to copy a patented drug, but only after it has been marketed for 3 years. The generic's maker however must pay a "reasonable" royalty
            4) Stopped evergreening
         c) +ve result - Increased R&D investments by generis giants to discover novel drugs for same disease e.g. 10% of revenues by DRL
      5) COVID
         a) Vaccines
         b) Drugs
            i) Chloroquine and Hydroxychloroquine - research on blocking viral protein synthesis
            ii) Ritonavir - reduce symptom severity and hospital stay
            iii) Corticosteroids - prevent cytokine storm and lung damage, but can cause reduced immunity and sugar levels, inviting other infections like black fungus
      6) Why India imports so much API? - dumping by China devastated India's industry growth

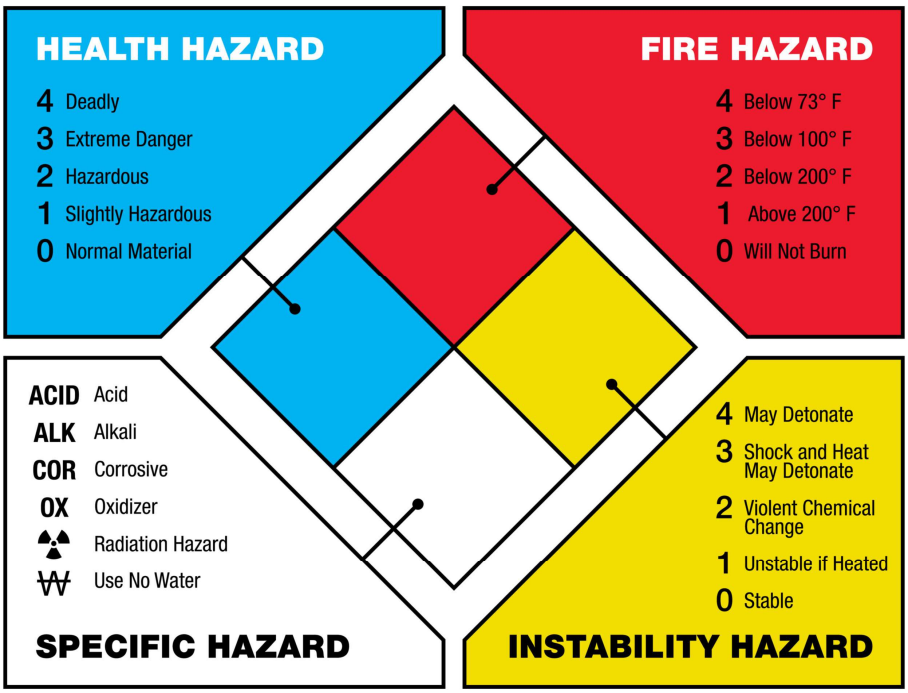
7) Generic drugs
    a) What are they? - drug with same API as original patented drug, commercialised after original patent expires
    b) India's global standing? - Rank 1 = 20% of global generics, 60% share in global vaccines
    c) Advantages for India? - OoPE, Make for the World, Global South, boost innovation, increasing older population
    d) Any concerns in future? - product patents after TRIPS, efficacy and testing of exported meds
    e) How will you work towards improving this sector's growth as an administrator?
        i) Ensure regular quality checks in smaller units
        ii) Dedicated scheme for infra upgradation for MSME units
        iii) Cold chain infra
        iv) No hoarding
        v) Focus on drug development for NTD, rare diseases

11. Why private companies are not interested in funding for research projects?
    a. High gestation period
    b. No assured results (profitability matters)
    c. I believe we need more Industry-academia collaboration - handholding support, cite IIT R&D model, this has become the backbone of major drug mfg giants like Pfizer

12. Which areas in chemical engineering should one pursue a startup in?
    a. BIOFUELS - 3rd gen - specially engineered energy crops such as algae
    b. BATTERIES
    c. Intermediate chemicals via carbon sequestration like propylene carbonate
    d. API production in pharma
    e. Green polymers like biodegradable plastics

13. Nitrogen hypoxia - Alabama, causes unconsciousness followed by death, considered less painful but still at experimental stage

14. SAFETY and CLEANLINESS IN INDUSTRIES
    a. Health, Safety and Environment (HSE) policy - for controlling workplace hazards, environmental risks, and employee well-being
    b. Fire diamond



c. Personal experience - CS2 storage under water in UPL plant b/c denser
d. HVAC - Heating, Ventilation and Air Conditioning unit. This ensures that over 90% of the air is recirculated in the premises with an influx of 10% fresh air to maintain Oxygen levels
e. Airlocks - Air locks prevent cross contamination. Eg - Cascade Airlock where the room with higher standards of purity has to be maintained at a higher pressure. This ensures that air won't flow from the less pure corridor/ room at lower pressure to the ones at higher pressure.
f. Biodegradable medical waste is produced everyday and sent to incinerators to be burnt and sent to cement factories
g. Some conventions
    i. Rotterdam - calls on exporters of hazardous chemicals to use proper labeling, include directions on safe handling, and inform purchasers of any known restrictions or bans
    ii. Minamata - Mercury usage
    iii. Chemical Weapons Convention - Disarmament Treaty which bans the development, production, acquisition, transfer, use and stockpile of all chemical weapons
        1) India is a signatory and party to CWC of the Organization for the Prohibition of Chemical Weapons (OPCW) with Head Quarters at The Hague
    iv. Stockholm - POPs

15. Green Chemistry
    a. Design of chemical products that reduce and may even eliminate production of hazardous substances
    b. Some Principles of Green Chemistry
        i. Prevent waste
            1) Maximize atom economy
            2) Use catalysts, not stoichiometric reagents
            3) Use renewable feedstock - from agriculture or wastes of other processes
        ii. Design safer chemicals and products - minimise accident hazard
        iii. Use safer solvents and reaction conditions
        iv. Increase energy efficiency
        v. Real time pollution control
    c. Especially significant for Pharmaceutical Industry, Paper & Pulp Industry, Polymer Industry, Sugar & Distillery Industries, Textile and Tannery Industry

16. ZLD / Liquid waste management techniques
    a. Reverse Osmosis - liquid is passed through the set of nanomembranes where the 'reject' stream with higher TDS is removed
    b. Distillation of permeate stream to recover solvents, reject stream is crystallised to recover API
    c. Effluent Treatment Plant (Zero Liquid Discharge Plant)
        i. Low COD
            1) Primary- Sedimentation (alum/clarification) - Alum is hydrated potassium-Aluminium double salt
            2) Secondary- Bio-oxidation, aeration, classification
            3) Tertiary- RO rejects go to Multi-effect evaporator (declining pressures in each column)
        ii. High COD
            1) Stripping- Recover solvent using Vapor-liquid extraction, mostly steam is used to recover acetone from liquid stream in say, tray towers
            2) MEE and Agitated Thin Film Evaporator (ATFE) - water recovery
    d. E-Factor = Waste generated (kg) per kg of product

17. Basic terminologies and explanation
    a. Process flow diagram (PFD) - streams info (name, flow rates, T,P), equipment stylised drawings with specifications at bottom
    b. Piping and Instrumentation diagrams (P&ID) - shows the engineering details of the equipment, piping, valves, fittings, instrumentation and controls, instruments drawn roughly to scale
    c. Heat exchangers
        i. Types based on flow - concurrent, counter, cross
        ii. Shell and Tube HEX - incoming -- turn -- return coils

iii. Air-cooled HEX - big blowers at bottom, straight pipes on top
iv. Plate type HEX - much larger surface area, efficiency than S&T HEX, easy to change and repair plates BUT costly and frequent cleaning for dirty fluids
v. Double pipe HEX - concentric pipes

18. OIL ECONOMY
    a. Who does India import from?
        i. Russia - 36%, OPEC - 46%
    b. What is Windfall tax? Was it a good measure?
        i. Windfall Tax is imposed on an industry's profits when it experiences a sharp increase in revenue due to unrelated external events
        ii. These revenues cannot be linked to anything the company actively pursued, such as its business strategy or expansion
        iii. Positives - reduce trade deficit, redistribution of unexpected gains, welfare schemes
        iv. Negatives - bring uncertainty to market
    c. Imports from Russia criticised by West, your take? - India imports less oil from Russia in a month than Europe does in an afternoon
    d. Oil imports, how to reduce it - Biofuels, EV, Green H2
    e. Types of crude oil - sweet and sour based on 0.5% w/w, their sources.
        i. Sweet = Iraq (leading), Appalachian Basin in Eastern North America, North Sea of Europe, North Africa, Australia, and Far East including Indonesia
        ii. Sour = Venezuela is a leading producer of sour crude oil - also in Gulf of Mexico, Mexico, South America, and Canada
        iii. Reserves - Venezuela (>300 billion barrels) > Saudi Arabia (297.5 billion barrels)
    f. Refinery operations
        i. Desalter
        ii. Crude and vacuum distillations
        iii. Naphtha (C4-C10 including ringed, aromatic) hydrotreater for de-sulferisation
        iv. Catalytic reforming - convert low octane number linear paraffins into highly branched/aromatic products with higher Octane number
            - Octane number - a standard measure of a fuel's ability to withstand compression in IC engine (isooctane)
            - Cetane number - standard for combustion of diesel fuels
            - Fuels with lower octane (but higher cetane numbers) are ideal for diesel engines because diesel engines (also called compression-ignition engines) do not compress the fuel, but rather compress only air and then inject fuel into the air that was heated by compression
        v. Fluid Catalytic cracking - converts heavy into lighter compounds
        vi. Delayed coking - bottoms of distillation thermally decomposed into lighter products, and residual is Coking Coal
        vii. Isomerization units
        viii. Steam reforming of Methane

MINERALS/ASSOCIATED INDUSTRY

1. Semiconductor in India + related industries
    a. Why India going into this?
        i. Can support both high-end manufacturing and services sector
        ii. Aatmanirbharta - Covid
        iii. High quality employment
        iv. Export potential
            1) While India continues to manufacture a significant number of smartphones, most of it is consumed domestically
            2) Export share 4% vs Vietnam 12%

Target by 2026	a. $ 300 Bn mfg

	b. $ 120 Bn exports

b. Semiconductor mfg - Silicon ingots ----> slicing and preparation of silicon wafers ----> chip fabrication ----> downstream usage in telecom, IT industry
c. Key challenges faced currently?
    i. Quality power, tech and capital intensive
    ii. High gestation period
    iii. Global players already have pricing, brand and quality advantage
d. Key initiatives taken
    i. PLI for large scale electronics manufacturing
    ii. Comprehensive programme for dev of semiC and display mfg ecosystem
        1) 76 K Cr
        2) Gov support = 50% of firm's capex
        3) Upto 25% scheme outlay for R&D
        4) India = world's 20% semiC design engineers but low share in IP (US Chips and science act 2022 - 70% on R&D)
    iii. 'India's Techade: Chips for Viksit Bharat' program - PM laid the foundation stone for 3 projects worth about Rs 1.25 L Cr
        1) Nation's 1st Semiconductor fabrication facility at Dholera Special Investment Region (DSIR)
        2) Outsourced Semiconductor Assembly and Test (OSAT) facility at Morigaon, Assam
        3) Outsourced Semiconductor Assembly and Test (OSAT) facility at Sanand, Gujarat
    iv. Micron SemiC facility in works - however limited to only packaging of SemiC chips, instead of production

2. Rare Earth Metals
    a. What are they? Why are they useful? - 17, RE technology, battery, alloys
    b. Why India import dependent?
        i. Only 6% of global reserves VS China 37%
        ii. Underexplored reserves - clearance issues
        iii. Limited to 'low cost low reward' upstream processes
    c. How do we tackle Chinese monopoly?
        i. GSI big role to play
        ii. Need Exploration in IOR
        iii. Supply chain resilience - Mineral security partnership for REE, Ni, Co, Li, Khanij Bidesh India Limited (KABIL) exploration in ABC, Aus
        iv. Effective recycling ecosystem - 40% reduction in demand if recycling of REE from old household appliances like phones, hard drives, motors and turbines

3. Critical minerals
    a. GoI identified 30 critical minerals for India - including 6 PGE, 15 REE and other 28 elements
    b. What are the related env issues?
        i. Water intensive - 2.2 million litres of water for one tonne of lithium
        ii. aquifer contamination
        iii. GHG intensive - 15 tonne CO2 per tonne of Li extracted
        iv. Nature of geological reserves - Li-bearing pegmatite deposits of Aus are in stable continental rocks, unlike the young and unstable Himalayas (Reasi district in J&K) -----> higher socio-env cost
    c. Case - Chile's National Lithium Strategy 2023 - calls for PPP for future projects, allowing state to regulate env impact of mining, distribute revenue fairly among local communities and promote domestic research into lithium based green technologies
    d. MoU

Li	5 Lithium mines to be jointly explored, developed in Argentina by KABIL and Argentina State Mining agency @ Rs 200 Cr
Co	DRC
Ni	Indonesia

Cu	Chile

4. Fossil fuels
    a. You are a chemical engineer, how do you see the issue of fossil fuel in recent times
        i. Global energy mix - 65% FF, 25% RE + biofuels, 10% nuclear
        ii. Current focus is on phase-down (highlights a gradual exercise to not harm LDC, Developing world)
        iii. Simultaneous enhancement of RE capacity
        iv. Developed world wants to deliberately protect NG and push for coal phase-out - UNJUST
    b. Petrol vs Diesel - which is more polluting?
        i. Petro - less PM, NOx
        ii. Diesel - less CO, more efficient engine
    c. What is government doing to reduce dependence on fossil fuels
        i. Biofuels
        ii. EV
        iii. H-CNG
    d. Don't you think that overuse of fossil fuels are not good for India and India should also try to phase out the use of fossil fuel very soon?
        i. We are already committed to do so by balancing our economic and environmental commitments
        ii. FF in short run BUT ALSO
            1) Cleaner processes - fly Ash for roads, cement
    e. CNG vs Gasoline - bad on CO front, all else better
    f. BS norms
        i. Bharat stage emission standards (BSES) are emission standards instituted by GoI to regulate exhaust from compression ignition engines
        ii. BS 5 skipped because BS3 to BS4 took more than a decade and BS engine tech already present, why to wait more..
        iii. SOx, NOx, PM all lower for BS6 fuel
    g. Any developed country who is relying on fossil fuels and why they are not taking action on reducing it?
        i. US - 80% energy needs
        ii. Reasons - natural reserves, existing infra, locals oppose - tribals, heating, noise
    h. What are the steps taken by government towards green energy infrastructure?
        i. Targeted approach based on geographical suitability
        ii. Bhadla (RJ), Jaisalmer (RJ), Puga (Ladakh)
    i. Why the timeline of reducing the use of fossil fuel was not finalized at COP 28?
        i. Climate denialism - CoP 28 President said no science behind phase out of FF and attaining 1.5 deg target
        ii. Phase out vs Phase down
        iii. Say of Oil and NG exporting nations
        iv. RE investments - developed nations yet to be become torchbearers in tech and fund sharing
    j. How will you promote green energy infra?
        i. Public TP - EV, H-CNG
        ii. RE based on select geography

5. Hydrogen
    a. Production
        i. GREEN - electrolysis using RE
            1) Development of Green Hydrogen production capacity of at least 5 MMTPA
            2) Over ₹1 L Cr reduction in fossil fuel imports
            3) Advantages - Panchamrit commitments, only H2O no NOx, SOx, PM, 3X more efficient than petrol
            4) Key challenges for Green H2 at present?
                a) 2-3X higher production cost than Grey H2
                    1) Electrolyser import dependence for critical earth metal, PGM, nickel
                b) Distilled water supply
                c) lack of fuelling station infrastructure
                d) Safety - explosive, no smell
            5) What are we doing about it?

a) NGHM
b) MNRE meet on new H2 gas storage tanks - withstand high pressure but also light - use carbon fibre
c) 18% H-CNG blend notified
d) MSP for resilience in imports

ii. BLUE = GREY or BROWN if CCUS
iii. PINK - electrolysis using Nuclear energy
iv. GREY - Steam gas reforming
1) For this process, high temperature steam (H_2O) reacts with methane (CH_4) in an endothermic reaction to yield Syngas
$CH_4 + H_2O \rightarrow CO + 3\ H_2$
2) In a second stage, additional hydrogen is generated through the lower-temperature, exothermic, water-gas shift reaction, performed at about 360 °C (680 °F)
$CO + H_2O \rightarrow CO_2 + H_2$
v. BROWN

1) Coal gasification

a) Coal seam injection of steam and air
3C (i.e., coal) + O_2 + $H_2O \rightarrow H_2$ + 3CO + some CO_2
b) Water gas shift
$CO + H_2O \rightarrow CO_2 + H_2$
c) Safety issues of CO - 150-200 ppm can cause unconsciousness or even death
d) NOTE - GoI has approved a scheme to promote coal/ lignite gasification projects @ Rs. 8,500 crore of investment outlay under 3 categories i.e. for Govt PSU's, Private Players and Small Scale Projects
e) Advantages of Coal gasification
i) Especially useful to 'extract' non-profitable mining coal - dig 2 pipes
ii) Also to utilise low grade peat coal
iii) Relatively cleaner process compared to direct coal burning - can assist gradual transition away from Coal thermal PP in developing countries like India
iv) Hydrogen ----> can also make Methanol ---> higher hydrocarbons ----> indigenous industry saves forex

2) Partial oxidation of heavy oils
$C_{12}H_{24} + 6\ O_2 \rightarrow 12\ CO + 12\ H_2$

b. Why focus on Hydrogen fuel cells now?
i. Miniaturisation tech developing
ii. CC severe

6. Fertilisers
a. Import dependence
i. How much? - 30% urea, 90% phosphates, 100% potash
ii. Why India imports? Does it not have its own plants to produce DAP, MOP?
1) DAP or (NH4)2HPO4 - raw material is rock phosphate/phosphorite (calcium phosphate ore) found in Udaipur, Banswara, UP, MP, AnP
2) MOP or KCl - No commercially viable reserves, some in Karauli and Sawai Madhopur, UP, MP
3) Ministry of C&F pushing for Aatmanirbharta
b. Tell me which type of subsidy is given to fertilizer?
i. NBS for non-urea - decentralised prices
ii. MRP fixed for Urea
c. Can you explain me the procedure/process like how government is providing subsidy in fertilizer?
i. E-Urvarak DBT platform
d. PM PRANAM
i. Full form? - PM Programme for Restoration, Awareness, Nourishment and Amelioration of Mother Earth
ii. To reduce subsidy burden on govt, promote alternate nutrients
iii. Data available on Integrated fertilizers Management System (iFMS) will be used for providing grants by comparing a state's increase or reduction in urea in a year, to its average consumption of urea during the

last three years

iv. 50% subsidy savings as grant to saver states of which:
    1) 70% used for asset creation related to technological adoption of alternate fertilizers
    2) 30% used to reward and **encourage farmers, panchayats** involved in fertiliser reduction and awareness generation

e. Urea
    i. Liquid Nano Urea
        1) Efficiency increase 80%, demand decrease 50%
        2) Control viral and fungal diseases
        3) Nano-DAP, Cu, B, Zn etc. in pipeline of Indian Farmers Fertiliser Cooperative Limited (IFFCO)
    ii. Neem-coated Urea (biopesticide, slow nitrification)
    iii. Sulphur coated Urea (Urea Gold) introduced to address S deficiency, more economical and efficient than Neem-coated urea

7. Notable chemical engineers
    a. All time
        i. Francis Bacon - World's 1st practical Hydrogen fuel cell
        ii. Carl Bosch - Haber-Bosch process for Ammonia preparation (Food security)
        iii. Ernst Solvay - Solvay ammonia Soda process, Na2CO3 used in glass, soap, paper, detergent
    b. Present
        i. Raghunath Mashelkar
            1) Former DG of Council of Scientific and Industrial Research (CSIR)
            2) Fought US turmeric patent case on wound healing properties, since it was traditional knowledge
            3) Creation of India's Traditional Knowledge Digital Library
            4) All 3 civilian awards except Bharat Ratna
        ii. Prof. Leja Hattiangadi - vast industrial experience, visiting prof. at IITB
        iii. Mukesh Ambani

8. Notable Chemists
    a. CNR Rao
        i. All 4 civilian honors
        ii. Work on Superconductors, transition metal oxides, carbon nanotubes
        iii. Nano mission under his leadership
    b. Prof. Chaitan Khosla - protein chemistry, over 134 scientific publications and 16 patents

9. How will it help in admin?
    a. Water - conservation, purification (STP), production (desalination)
    b. Env chemistry
    c. SWM, LWM, understanding pollutants
    d. Regulation of industries in my jurisdiction - pollution control norms, waste disposal systems, safety instruments and equipment in place

10. Daily chemistry
    a. Composition of fat in human body
        i. For people aged 20 to 39, women should aim for 21% to 32% of body fat. Men should have 8% to 19%
        ii. On average, women have 6 to 11 percent more body fat than men. Studies show oestrogen reduces a woman's ability to burn energy after eating, resulting in more fat being stored around the body. The likely reason is to prime women for childbearing
        iii. The three most common fatty acids stored in human adipose tissues are oleate (C18 H34 O2), palmitate (C16 H32 O2), and linoleate (C18 H32 O2),1 2 which all esterify to form C55 H104 O6 .
        iv. The complete oxidation of a single triglyceride molecule involves many enzymes and biochemical steps, but the entire process can be summarised as: C55 H104 O6 +78O2 →55CO2 +52H2 O+energy
        v. Stoichiometry shows that complete oxidation of 10 kg of human fat requires 29 kg of inhaled oxygen producing 28 kg of CO2 and 11 kg of H2 O.
    b. what is role of fat in body

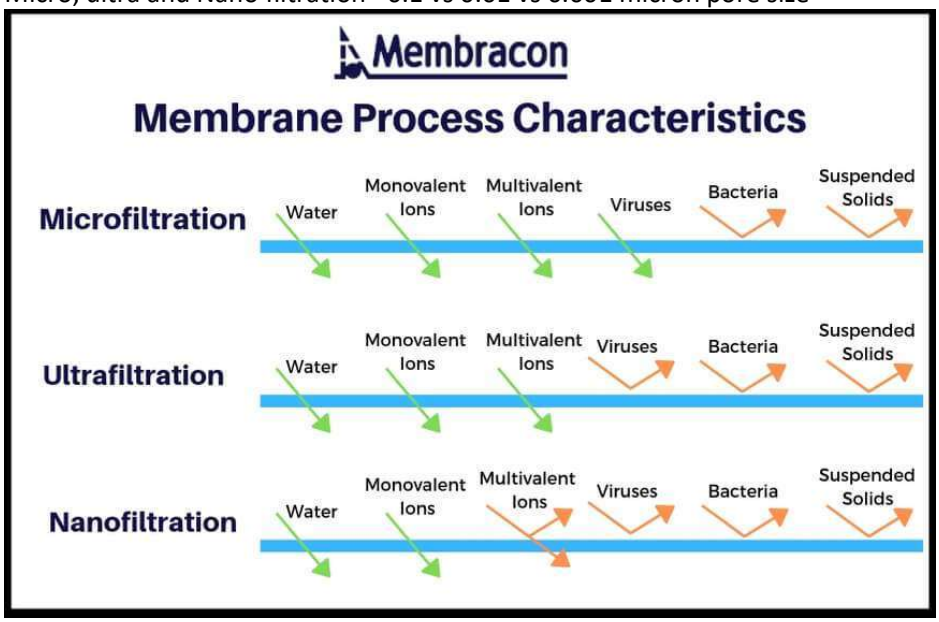
i. Carrier for fat-soluble Vitamins A, D, E, K - help their absorption from intestine
ii. Source of energy - 9 kcal per g vs 4 kcal per g in Carbs
iii. Membranes around cells and tissues - exchange of material

c. Alkaline water - pH 8-9 vs for normal water, experiments in mice suggested delay in ageing but no concrete evidence, body adjusts pH to 7.35-7.35 range, side effects not discovered yet
d. Heavy water, what if I drink it? - not harmful for a cup or 2, but too much slows down chemical reactions in body (Kinetic Isotopic effect) and can be fatal
e. COD vs BOD
    i. COD is similar to biochemical oxygen demand in that they are both used to calculate the oxygen demand of a water sample.
    ii. The difference between the two is that COD measures everything that can be oxidised, whereas BOD only measures the oxygen demanded by microbes under aerobic conditions
    iii. Higher BOD and COD means less DO available for organisms and much of it utilised by microbes for oxidation of organic matter
f. Hot ice?
g. Why divers use He instead of N2, although both are inert? - When they come back to the surface, solubility of nitrogen decreases and it separates from the blood and forms small air bubbles. This leads to a dangerous medical condition called bends. Helium has very low solubility in blood
h. An example of man-made element? All transuranic elements
i. Isotope, isobars, isotone,? - Z same, A same (Ar, Ca), n same (K, Ca)
j. How intensity of blast is measured? What is TNT?
    i. In term of tonne of TNT equivalent - Tri-nitro toluene
    ii. 1 tonne TNT = 4.184 GJ
k. How is Medical O2 different from normal O2? How is it produced? - Cryogenic distillation of air
l. Acid victim first aid? - lots of cold water or even milk, followed by NaHCO3
m. Why chemical engineers called big-bucks engineers?
n. Which chemicals can be extracted from e-waste?

11. POLLUTION
    a. Marine pollution
        a. Legal framework
            1) UNCLOS 1982 - calls signatory states to develop a legal framework to prevent, reduce and control pollution of the marine environment by dumping. India is a signatory to UNCLOS - broader UNCLOS motive is to define coastan and maritime boundaries, regulate seabed exploration
            2) International Convention for the Prevention of Pollution from Ships (MARPOL) is adopted in 1972, it bans the disposal of plastics in the sea. India is a signatory to MARPOL.
        b. global average of plastic per capita consumption is 28 kg (India 11 kg)
        c. Micro-plastics, SUP
            1) How to reduce plastics consumption
                a) Circular economy, formalisation of ragpickers
                b) Alternatives - jute bags cheaper in long run, Bagasse products like utensils
            2) I take efforts at my level but still there is plastic packaging and all, how to reduce it
    b. Inland and underground water pollution
        a. Key polluters - oil refineries, paper and dye factories
        b. Clean Ganga project
            1) Nirmal Dhara, Aviral Dhara, Gyan ganga, Jan Ganga, Arth Ganga
            2) Natural farming, Monetisation of treated water (sold to PSUs) and sludge (reusable products), Livelihood (Ghaat pe Haat), Cultural heritage and tourism (Ganga Artis)
        c. Rat-hole mining - unsafe mining practice prevalent in Meghalaya to extract tertiary coal seams which are S rich, Kopili pollution, Uttarakhand tunnel collapse
    c. Air pollution
        i. Smog towers
            1) Downdraft tower in Delhi (sucks air from above, releases from below) - TPL with IIT Delhi, IIT Bombay as technical advisors
            2) IIT Bombay analysis - cleans air with 50% efficiency that drops to 30% at a distance of 50 meters

from the filters, and just above 10% when 500 meters away

ii. Micro, ultra and Nano filtration - 0.1 vs 0.01 vs 0.001 micron pore size



iii. Pollutants and GHG - AQI by NAMP (PM10, PM2. 5, NO2, SO2, CO, O3, NH3, and Pb)

Red	Strontium
Orange	Calcium
Yellow	Sodium
Green	Barium
Blue	Copper

12. Biofuels
    a. Why not methanol - corrosive, easy availability of ethanol, calorific value low
    b. Why only 20%?
        i. Already having Flex-fuel vehicles - E85
        ii. MoRTH - pilot project on Flexi-Fuel Strong Hybrid Electric Vehicles (FFV-SHEV) - 100% petrol or 100% ethanol or 20 to 100% blended ethanol + Battery
    c. What steps taken to ease adoption of biofuels?
        i. GST on ethanol meant for Ethanol Blended with Petrol (EBP) Programme from 18% to 5%
        ii. VGF for biorefineries
        iii. PM JIVAN - promoting 2G ethanol production

13. Battery technology
    a. Different types of batteries - lead acid, Li-ion, Ni-Cd, Sodium battery (lesser energy density than Li-ion)
    b. Lithium reserves discovered recently?
        i. Degana in Nagaur RJ
        ii. Reasi in J&K
        iii. Mandya in Karnataka
    c. What are the advantages associated with the use of Lithium ion batteries?
        i. > 80% efficiency
        ii. Low maintenance, rechargeable (secondary battery)
        iii. High energy density
        iv. Light weight
    d. Is India capable of producing it? - PLI for advanced chemistry cells, produced in Gurugram and Hyderabad
    e. What is so new about batteries used in EV
        i. Solid state batteries - safer (lesser volatile elements), higher energy density
        ii. Lithium-Sulfur batteries - cheaper, lighter, energetically denser

iii. Lithium-Iron phosphate batteries - durable, safer but lower energy density
iv. Lithium titanate - best in all counts except energy density, used for space missions
v. Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO2) — NMC - higher Energy density, lower safety

f. How does Solid State Lithium Battery work? - cathode (Li+ and CoO2 combine) and anode (Li-C6 breaks)
g. Reasons for dominance of China?
   i. Subsidised both production and sale (as high as 33% of sale value) for almost a decade (2000s)
   ii. However limited success - battery price and low charging infra
   iii. Industry carrot - Consistent R&D in batteries, linking EV subsidy to battery performance, increasing competition for domestic producers by bringing Tesla (Shanghai mfg facility)
   iv. Consumer carrot - very easy registrations for EV than petrol cars, battery replacement facilities (faster)
   v. Now largest global EV seller is China's BYD, not Tesla
h. What is the future of lithium battery and EVs in India? - very bright, support Panchamrit commitments, lithium reserves + MSP can help
i. There is climate change issue so we are pushing the manufacturing of EVs, why can't we just import rather taking long time in manufacturing as CC is bigger problem? - Sir CC is here to stay, if we start importing now and do not develop indigenous mfg, we will be perpetually dependent since global firms will lead us in competitive advantage and efficient mfg, India being an Early bird is certainly desirable, besides quality employment and export potential will help GDP growth
j. What are the challenges in increasing EV adoption - 60% rural population, charging infra, initial investment
k. What are the challenges w.r.to EV subsidies? - preventing wastage (China)
l. Why EV catching fire?
   i. Short circuit raises localised heat, fault in Battery Management System (BMS) unable to regulate T, Battery and wiring quality, Accidental damage causing battery rupture and hot oil contact
   ii. Key concern = THERMAL RUNAWAY when one cell after another keep on catching fire
   iii. Use lots of water to lower battery unit T and control fire
m. Considering that most of the electricity presently is produced from coal plants, is EV adoption, a feasible option? - already pushing for renewables, Rooftop solar, offshore wind etc.
n. What is the per capita energy consumption in India? 1255 KWh per capita per annum, only 1/3 of global avg
o. Is it greater or lesser than China? China 4-5X more than India
p. Policy of battery recycling - Battery Waste Management Rules, 2022
   i. Cover all types of batteries, viz. Electric Vehicle batteries, portable batteries, automotive batteries and industrial batteries
   ii. Producers (including importers) of batteries are responsible for collection and recycling/refurbishment of waste batteries and use of recovered materials from wastes into new batteries
   iii. Store for <=180 days and keep record
   iv. Env compensation for EPR violation
   v. Centralized online portal for exchange of EPR certificates between producers and recyclers/refurbishers to fulfil the obligations of producers
q. Policy of battery swapping - deliberations on by DST, BIS, Niti Ayog
r. How to attract Global EV firms
   i. Want import duty cuts (from 60-100% to 15-40%) in short term in return for establishing assembly lines in India, examples are Tesla and Vietnam's Vinfast
   ii. India announces lower import taxes on certain electric vehicles for companies committing to invest at least $500 million and setting up a local manufacturing facility within three years
   iii. Firms meeting these requirements will be allowed to import 8,000 EVs a year at a reduced import duty of 15% on cars costing $35,000 and above
s. Ministry of Heavy Industries signs an MOU with Indian Institute of Technology, Roorkee to establish a Centre of Excellence and an Industry Accelerator to drive innovation in the automotive and electric vehicle sectors

14. Solar power
   a. Light bulb consumes 60-100 W per hour
   b. PM Suryodaya Yojana
      i. What is it? - for rooftop solarisation in 1 Cr HH, will add 20-25 GW
      ii. Why needed? - missed rooftop target (40/100 GW vs 11/73 GW actual - only 15% of solar mix)
      iii. Advantages?

1) Energy security
2) Savings worth 18k per year
3) Adoption of EV - charging at homes

c. Approved Models and Manufacturers of Solar Photovoltaic Modules (Requirement for Compulsory Registration) Order, 2019, requires module makers to submit to an inspection of their manufacturing facilities by the National Institute of Solar Energy. Being on the list as an 'approved' manufacturing facility certifies a company as legitimately manufacturing solar panels within its premises and not importing modules.

15. Nobel prize
    a. Chemistry - discovery and synthesis of Quantum dots
        i. QDs are **fluorescent semiconductor nanocrystals,** composed of materials from the elements in the periodic groups of II–VI, III–V or IV–VI, e.g. indium phosphamide (In from group III and P from group V)
        ii. They range in size from 2 to 10 nm in diameter and contain approximately 200–10,000 atoms
        iii. QDs emit light and the size of nanocrystal determines the wavelength of light emitted by it. A **smaller quantum dot emits high-frequency photons with shorter wavelengths**
        iv. Applications:
            1) Bioimaging - 20X brighter
            2) LED screens
            3) Unique package identifier - security marker on docs
    b. Can you recall prize awarded in other fields?

16. Wet Bulb temperature
    a. The wet-bulb temperature is the temperature read by a thermometer covered in water-soaked cloth over which air is passed.
    b. At 100% relative humidity, the wet-bulb temperature is equal to the air temperature
    c. At lower humidity the wet-bulb temperature is lower than dry-bulb temperature because of evaporative cooling

17. White Phosphorus
    a. Catches fire on air contact

    b. Chemical weapons convention - not treats it as chemical weapon, it is often used to create smoke screens, illuminate targets, burn bunkers
    c. However illegal to use it as incendiary weapon in war zones and heavily populated civilian areas

18. Ozone
    a. Montreal protocol, Kigali amendment

b. Is India a member?
c. What is good and bad ozone
d. Recently US prosecuted person for importing cooling appliances with HCFC22, HFC