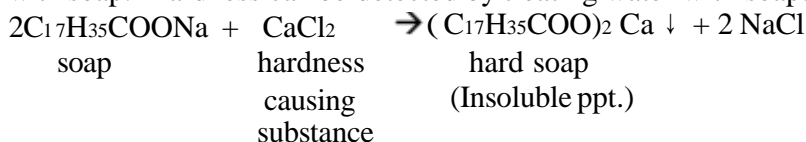


CY8151-ENGINEERING CHEMISTRY

UNIT – I WATER AND ITS TREATMENT PART A

1. Define hardness of water.

Hardness is the property or characteristics of water, which does not produce lather with soap. Hardness can be detected by treating water with soap.



2. What are the salts responsible for carbonate and non-carbonate hardness of water?

Carbonate hardness: $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$

Non-carbonate: $CaCl_2, CaSO_4, MgCl_2, MgSO_4$

3. Distinguish between carbonate (temporary) hardness (CH) and non-carbonate (permanent) hardness (NCH)

S.No	carbonate (temporary) hardness	Non-carbonate(permanent) hardness
1	This is due to bicarbonates of calcium and magnesium	This is due to chlorides and sulphates of calcium and magnesium
2	It can be removed boiling of water	It cannot be removed boiling of water
3	It is also called alkaline hardness	It is also called non-alkaline hardness

4.

S.No	Hard water	Soft water
1	Hard water does not produce lather with soap solution.	Soft water produces very good lather with soap solution.
2	It gives wine red colour with EBT indicator.	It does not give colour with EBT.

5. Why is water softened before using in boiler?

If hard water obtained from natural sources is fed directly into the boilers, the following troubles may arise,

- (i) Scale and sludge formation
- (ii) Priming and foaming (carry over)
- (iii) Caustic embrittlement
- (iv) Boiler corrosion.

6. What are scales and sludges?

Sludge: If the precipitate is loose and slimy it is called sludge. Sludges are formed by the substances like $MgCl_2, MgCO_3, MgSO_4$ and $CaCl_2$. They have greater solubilities in hot water than cold water.

Scale : On the other hand, if the precipitate forms hard and adherent coating on the inner walls of the boiler, it is called scale. Scales are formed by substances like $Ca(HCO_3)_2, CaSO_4$ and $MgCl_2$.

7. Why is demineralization process used for softening of water for use in boilers?

Demineralized water is free from all ions, whereas zeolite – softened water contains sodium salts (e.g., $NaCl$ and Na_2SO_4) which cause caustic embrittlement in boilers.

8. Mention any two compounds that cause caustic embrittlement in boilers.

Alkali metal carbonates and bicarbonates like Na_2CO_3 , K_2CO_3 , NaHCO_3 , and KHCO_3 .

9. Distinguish between soft water and demineralised water.

The soft water does not contain hardness producing ions, but will contain other ions. On the other hand, demineralised water does not contain both anions and cations.

10. What is meant by priming and foaming? How can they be prevented?

Priming : It is the process of production of wet steam. Priming can be prevented by controlling the velocity of steam and keeping the water level lower.

Foaming: It is the formation of stable bubbles above the surface of water. Foaming can be prevented by adding coagulants, like sodium aluminate and antifoaming agents like synthetic polyamides.

11. What is meant by caustic embrittlement? How is it prevented?

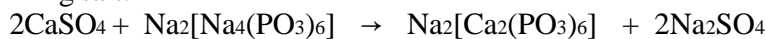
Caustic embrittlement means intercrystalline cracking of boiler metal.

Prevention: Caustic embrittlement can be prevented by

- (i) Using sodium phosphate as softening agent instead of sodium carbonate.
- (ii) By adding tannin, lignin to the boiler water, which blocks the hair cracks.

12. What is calgon conditioning? How is it functioning to water treatment?

Calgon is sodium hexa meta phosphate $\text{Na}_2[\text{Na}_4(\text{PO}_3)_6]$. This substance interacts with calcium ions forming a highly soluble complex and thus prevents the precipitation of scale forming salt.



13. What are boiler compounds? Mention two different boiler compounds and their actions.

Scale forming substances can be removed by adding chemicals directly to the boiler. These chemicals are called boiler compounds.

Examples: Sodium carbonate and Sodium phosphate.

- (i) $\text{CaSO}_4 + \text{Na}_2\text{CO}_3 \rightarrow \text{CaCO}_3 + \text{Na}_2\text{SO}_4$
- (ii) $3\text{CaSO}_4 + 2\text{Na}_3\text{PO}_4 \rightarrow \text{Ca}_3(\text{PO}_4)_2 + 3\text{Na}_2\text{SO}_4$

14. What is colloidal conditioning?

Scale formation can also be minimized by adding into the boiler some colloidal conditioning agents such as glue, agar agar, tannins, starches and sea-weed extract. These substances act as protective colloids. This process is called colloidal conditioning.

15. Why can caustic embrittlement be controlled by adding sodium sulphate to boiler – feed water?

When sodium sulphate is added to boiler-feed water, it blocks hair- cracks, thereby preventing infiltration of caustic soda solution. In this way sodium sulphate prevents caustic embrittlement in boiler.

16. Why is boiled water not always 100% safe for drinking purposes?

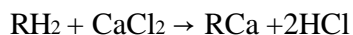
Boiling kills only the existing germs in water, but does not provide any protection against further possible contamination during storage, etc.

17. What are ion-exchange resins?

Ion exchange resins are long chain, cross linked, insoluble organic polymers with a micro porous structure. The functional groups attached to the chains are responsible for the ion exchanging properties.

18. How is water demineralized by using an ion- exchanger?

When water containing both anions and cations is passed through first cation exchanger and then through anion exchanger, all the ions are adsorbed by the two ion exchange columns. For example:



19. Phosphate conditioning is suitable at all-operating pressures? Give reasons to support this statement.

In high pressure boilers, an excess of a soluble phosphate is added to the boiler water to precipitate the residual calcium ions in the form of a non-adherent precipitate of calcium phosphate and thus the scale formation is prevented.

20. Differentiate between drinking water and boiler feed water.

S.No	Drinking water	Boiler feed water
1	Total dissolved solids including hardness producing salts should be less than 500 ppm	Total hardness should be zero and free from gases like CO ₂ , O ₂ etc.
2	p ^H of water may be 7.5-8.5	p ^H of water should be near to 7.

21. What is meant by reverse osmosis?

If pressure in excess of osmotic pressure is applied on the higher concentration side, the solvent flow is reversed i.e., solvent flows from higher concentration of lower concentration. This is called reverse osmosis.

22. What are the advantages of reverse osmosis method?

1. The life time of the membrane is high, and it can be replaced within few minutes.
2. It removes ionic as well as non-ionic and colloidal impurities.
3. Due to low capital cost, simplicity, low operating, this process is used for converting sea water into drinking water.

23. What is the purpose of the internal treatment of boiler feed water?

This method is used for the removal of scale forming substances which were not completely removed in the external treatment by adding chemicals directly in the boiler.

24. Write any two disadvantages of hardwater in boilers?

1. Scale and Sludge
2. Priming and Foaming
3. Caustic embrittlement
4. Corrosion

25. Mention any two disadvantages of formation of deposits in steam boilers

1. Wastage of fuel
2. Decrease in efficiency
3. Boiler explosion

PART B

1. How is internal treatment of boiler feed water carried out using phosphate and calgon conditioning?
2. What are boiler troubles? How are they caused? Suggest steps for minimizing the boiler

- troubles (or) Explain the boiler troubles, “scales and sludge” in detail. (or) What are sludge and scale in boilers? How are they formed? Suggest any two methods to prevent their formation.
3. Describe the process of demineralization of hard water using ion exchange resin.
 4. How is the exhausted resin regenerated in an ion –exchange method? What are the merits and demerits of ion –exchange method?
 5. Explain the disadvantages of scale formation.
 6. Explain briefly about boiler feed water and its requirements.
 7. Write short notes on: a) Boiler compounds b) Caustic embrittlement
 8. What are soft and hard scales? How they are removed?
 9. Explain internal conditioning of boiler feed water.
 10. Define desalination. Explain the reverse osmosis process of desalination of water. (or) What is reverse osmosis? How is it useful for desalination of brackish water? Explain with a diagram.
 11. Discuss in detail the problems caused due to the usage of hard water in boilers. How are they minimized by carbonate conditioning, phosphate conditioning and calgon conditioning? (or) What is meant by internal conditioning of water? Explain phosphate and carbonate conditioning with relevant equations.
 12. Distinguish between demineralized water and soft water. How is demineralized water prepared? (or) How is water softened by Ion exchange method? Explain in detail with a neat diagram.
 13. Compare carbonate conditioning and phosphate conditioning of boiler water with respect to the principles involved, advantages and limitations.
 14. Give principal of zeolite process? Write advantages, disadvantages and limitation of zeolite process. (or) What are zeolites? How do they function in removing the hardness of water? (or) What are zeolites? How are they used in softening of water? Use a diagram for your explanation?
 15. Explain with chemical equations the demineralization of hard water and regeneration of ion exchange resin.
 16. What are scales? What are its disadvantages and causes.
 17. Explain how boiler corrosion takes place due to presence of (i) dissolved O₂ (ii) dissolved CO₂ and (iii) Mg salts in boiler feed water. Give the removal methods for each.
 18. Explain the EDTA method of estimation of hardness of water. (or) What is meant by hardness? How will you determine hardness of water by EDTA method?
 19. 100 ml of water sample requires 20 ml of 0.01 M EDTA for the titration of EB-T indicator. 100 ml of the same water sample after boiling and filtering required 10 ml of 0.01 M EDTA. Calculate the total, carbonate and non-carbonate hardness of the water.
 20. 50 ml of hard water sample requires 35 ml of 0.01 M EDTA for the titration. 50 ml of the same water sample after boiling and filtering required 12 ml of 0.01 M EDTA. Calculate the total, temporary hardness of the water.
 21. Write short notes on the following:
 - a. Priming and foaming
 - b. Scales and sludge

UNIT – II
SURFACE CHEMISTRY AND CATALYSIS
PART A

1. Define adsorption.

The phenomenon of higher concentration of any molecular species at the surface than in the bulk of a solid is known as adsorption.

2. What are adsorbent and adsorbate?

The solid that takes up a gas or vapour or a solute from a solution is called the adsorbent. The gas or the solute which is held to the surface of the solid is called the adsorbate.

3) Distinguish between adsorption and absorption?

S.No.	Adsorption	Absorption
1	Adsorption is a surface phenomenon	Absorption is a bulk phenomenon
2	It is a rapid process	It is a slow process
3	Equilibrium is attained easily.	Equilibrium is attained slowly
4	It depends on the surface area of the adsorbent	No such effect

1. What are sorption and desorption?

The process in which both adsorption and absorption takes place simultaneously. The reverse of sorption, i.e. the release of the adsorbed or absorbed substances into the surrounding medium is termed desorption.

2. What is physical adsorption? Give an example.

The type of adsorption caused by the interplay of weak vanderwaal's forces is referred to as physical or vanderwaal's adsorption. Eg. Adsorption of H₂ or O₂ on charcoal.

3. What is chemisorptions? Give an example

If the adsorbate are held on the surface of the adsorbent by chemical bonds, it is called chemisorptions or activated adsorption.

Eg. Adsorption of H₂ on Nickel.

S. No.	Physisorption	Chemisorption
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1	It is caused by weak intermolecular vanderwaal's force.	It is caused by chemical bond formation.
2	It occurs at low temperature.	It occurs at high temperature.
3	It is reversible in nature.	It is irreversible in nature.
4	Does not show any specificity.	It is highly specific.
5	It is multilayer phenomenon	It occurs only in the upper layer.

4. How does chemisorptions differ from physisorption?

5. Write any four characteristics of adsorption?

- i) Adsorption is a spontaneous process.
- ii) It is accompanied by evolution of heat.
- iii) It is a selective process.
- iv) It is specific in nature.

6. Mention the factors which influence the adsorption of gases on solids.

- i) Pressure ii) Temperature iii) Nature of gases iv) Nature and surface area of adsorbent

7. What is the effect of temperature and pressure on the adsorption of hydrogen gas on charcoal?

Adsorption of hydrogen on charcoal is rapid at lower temperature and decreases with increase in temperature.

The rate of adsorption increases with the increases of pressure.

8. What is adsorption isotherm?

Adsorption isotherm is a relationship between magnitude of adsorption with pressure at constant temperature. $x/m = k p^{1/n}$

9. What is Freundlich's adsorption isotherm?

The relationship between the magnitude of adsorption(x/m) and pressure (p) can be expressed mathematically by an equation known as Freundlich's adsorption isotherm.

$$x/m = k p^{1/n}$$

10. Explain the limitations of Freundlich's adsorption isotherm.

- i) Freundlich isotherm is purely empirical and has no theoretical basis.
- ii) The equation is valid only upto a certain pressure and is invalid at high pressure.
- iii) The constants k and n are depending on temperature.

11. What is Langmuir adsorption isotherm? Write its mathematical form.

The relationship between the amount of gas adsorbed to the pressure of the gas at constant temperature is known as Langmuir adsorption isotherm.

Its mathematical form is $x = K' KP / 1 + KP$

12. Write the demerits of Langmuir's adsorption isotherm.

This isotherm holds good at lower pressure but fails at high pressure.

13. How arsenic poisoning is removed from the body?

Colloidal ferric hydroxide is administered which adsorbs arsenic poison and is removed from the body by vomiting.

14. Define catalyst.

It is a substance which alters the rate of a chemical reaction, itself remaining chemically unchanged at the end of the reaction.

15. What are the types of catalysis?

There are two main types of catalysis. They are

- i) Homogeneous catalysis
- ii) Heterogeneous catalysis

16. What is a homogeneous catalysis? Give example.

In homogeneous catalysis the catalyst is in the same phase as the reactants and is evenly distributed throughout.

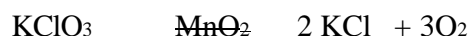
Example: Hydrolysis of sucrose in aqueous solution in presence of mineral acid catalyst.



17. What is heterogeneous catalysis? Give example.

The catalysis in which the catalyst is in a different physical phase the reactants is termed heterogeneous catalysis.

Example: The decomposition of potassium chlorate is catalysed by manganese dioxide.



18. Write any few criteria of catalysis? Give example.

- i) A catalyst remains unchanged in mass and chemical composition
- ii) Only a small quantity of the catalyst is required.
- iii) The catalyst does not alter the position of equilibrium in a reversible reaction
- iv) The catalyst is specific in action

19. Define auto catalysis. Give example

When one of the product of a reaction itself acts as a catalyst for that reaction, the phenomenon is called auto catalysis.

Example : the hydrolysis of ethyl acetate forms acetic acid and ethyl alcohol. Among these products, acetic acid acts a catalyst for the reaction.



20. What is catalytic promoter? Give an example.

A substance which promotes the activity of the catalyst to which it is added in small amounts is known as catalytic promoter.

In the Haber's process of ammonia manufacture, iron acts as a catalyst and Molybdenum acts as promoter.

21. What is catalytic poison? Give an example.

A substance which reduces or destroys the catalytic activity of a catalyst is known as catalytic poison. Eg: In the contact process of sulphuric acid manufacture, platinum is the catalyst and traces of arsenic compounds are catalytic poison.

22. What is an acid base catalysis? Give examples.

A large number of homogeneous catalytic reactions are brought about by acids or bases or both acids and bases. These reactions are called acid-base catalysis. Examples:

- i) Ester hydrolysis $\text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O} \longrightarrow \text{CH}_3\text{COOH} + \text{C}_2\text{H}_5\text{OH}$
- ii) Mutarotation of glucose

23. What is catalytic converter? Mention its type.

A catalytic converter is an emissions control device. This converts toxic gases and pollutants in exhaust gas to less toxic pollutants by catalysing a redox reaction.

Types : (i) 2- way converter (ii) 3- way converter

24. What is an enzyme catalysis?

The catalysis brought about by enzymes is known as enzyme catalysis.

25. Write Michaelis –Menton equation and explain the terms involved.

$$\text{Rate} = \frac{K_3 [\text{E}_0] [\text{S}]}{[\text{S}] + K_m}$$

26. Define K_m .

Michaelis –Menton constant (K_m) is equal to that concentration of substrate at which the rate of formation of product is half the maximum rate obtained at high concentration of substrate.

$$K_m = \frac{k_2 + k_3}{k_1}$$

27. Define turn over number.

The constant k_3 is known as turn over number. It is the number of molecules converted into products in unit time by one molecule of enzyme.

- 1.
- 2.
- 3.

4. Define the term adsorption and list its application.
5. (i) Give any three factors on which adsorption depends.
(ii) Derive Freundlich's adsorption isotherm. Give the conditions in which it fails.
6. Enumerate the factors influencing the adsorption of gases on solids. Derive the Langmuir adsorption isotherm and interpret the results at 1. Low pressure and at 2. high pressure.
7. Define adsorption isotherm. Explain the various types of adsorption isotherm.
8. Explain the role of adsorbents in pollution abatement or Discuss the role of activated carbon in the abatement of air pollution and waste water treatment.
9. Applying Michaelis and Menten equation discuss the kinetics of enzyme catalysed reaction.
10. Mention important characteristic features of enzyme catalysis.
11. Give the mechanism for enzyme catalyzed reaction as proposed by Michaelis and Menten. Write the rate equation for enzyme catalyzed reaction and what do the various terms in it stand for. What happens to the rate if 1. $[S] < k_m$ 2. $[S] > k_m$?
12. Explain the following with suitable examples Heterogeneous catalysis and Acid -base catalysis.
13. Mention the important applications of catalysts.
14. What are acid -base catalysis? Explain the mechanism and kinetics of acid -base catalysis.
15. What are the differences between homogeneous catalysis and heterogeneous catalysis.
16. Explain the terms, autocatalysis and negative catalyst.
17. Explain the functions of catalytic converters.

UNIT – III ALLOYS AND PHASE RULE
PART A

1. Define an alloy (or) what are alloys? (Jan 2014)

A homogeneous solid solution of two or more different elements in which at least is essentially a metal.

2. Mention the purpose of alloy making. (Dec 2014)

- i. To increase the hardness of the metal.
- ii. To resist the corrosion of the metal.
- iii. To lower the melting point of the metal.
- iv. To modify chemical activity of the metal.
- v. To modify the colour of the metal.
- vi. To get good casting of metal.

3. What are the objectives of heat treatment?

Heat treatment causes (i) Improvement in magnetic and electrical properties (ii) Refinement of grain structure (iii) Removal of the imprisoned trapped gases (iv) Removal of internal stress and strain (v) Improves abrasion and corrosion resistance.

4. Mention some important properties of ferrous alloy.

- i. They possess high strength and high yield point.
- ii. They possess sufficient formability, ductility and weldability.
- iii. They are sufficiently corrosion and abrasion resistant.
- iv. Distortion and cracking are less.
- v. They have high temperature strength.

5. What is nichrome? Give its composition and uses. (June 2014)

It is an alloy of Nickel and chromium. Composition: Ni-60%; Cr-12%; Fe-26%; Mn-2%

Uses: (1) Used for making resistance coils (2) It is used in making parts of boilers, gas turbines,

aero-engine valves, retorts and annealing boxes.

6. What is meant by 18/8 stainless steel?

It contains Cr-18% and Ni-8%.

7. What are stainless steels?

These are alloy of steels containing chromium together with other elements such as nickel, molybdenum, etc., Chromium is effective if its content is 16% or more. The carbon content in stainless steel ranges from 0.3 to 1.5%.

8. What is annealing? Explain its types.

Annealing means softening. This is done by heating the metal to high temperature, followed by slow cooling in a furnace. Annealing can be done in two ways.

1. Low temperature annealing (or) process annealing.
2. High temperature annealing (or) full annealing.

9. What is meant by quenching in heat treatment of metals?

It is the process of heating steel beyond the critical temperature and then suddenly cooling it either in oil or brine-water or some other fluid is called hardening or quenching.

10. What is tempering?

It is the process of heating the already hardened steel to a temperature lower than its own hardening temperature and then cooling it slowly.

11. State phase rule and explain the terms involved.

The equilibrium between any number of phases is not influenced by gravity or electrical or magnetic forces but are influenced only by pressure, temperature and concentration, then the number of degree of freedom (F) of the system is related to number of components (C) and number of phases (P) by the following phase rule equation,

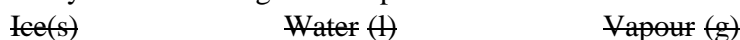
$$F = C - P + 2.$$

12. Define phase (p) with suitable example.

Any homogenous physically distinct and mechanically separable portion of a system which is

separated from other parts of the system by definite boundaries

Eg: Consider water system consisting of three phases



Each phase is physically distinct and homogeneous and there are definite boundaries between phases. So it forms three phases P = 3.

13. Define component with suitable examples. (Dec 2015 & Jan 2016)

The smallest number of independently variable constituents, by means of which, the composition

of each phase can be expressed in the form of a chemical equation.

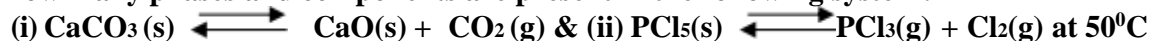
Eg: Ice (s) Water (l) Vapour (g)

The chemical composition of all the three phases is H₂O, but it is in different physical form. Hence the number of component is one C = 1.

14. What is meant by degree of freedom? (June 2016)

The minimum number of independent variable factors such as temperature, pressure and concentration, which must be fixed in order to define the system completely.

15. How many phases and components are present in the following system?



(i) P = 3; C = 2 ; F = C - P + 2 = 2 - 3 + 2 = 1

(ii) P = 3; C = 2 ; F = C - P + 2 = 2 - 3 + 2 = 1

16. Write the number of phases and components in the following heterogeneous system.



Number of Phases = 3

Number of Components = 2

17. What is condensed phase rule (or) State reduced phase rule (Jan 2016)

- ✓ Solid-liquid equilibrium of an alloy has practically no gaseous phase and the effect of pressure is negligible. Therefore, experiments are conducted under atmospheric pressure.
- ✓ Thus the system in which only the solid and liquid phases are considered and the gas phase is ignored is called reduced phase rule or condensed phase rule.

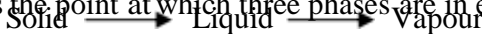
$$F' = C - P + 1$$

18. $\text{NH}_4\text{Cl}(s) \rightleftharpoons \text{NH}_3(g) + \text{HCl}(g)$. Write the values of P, F and C for this system?

P = 2; C = 1 ; F = C - P + 2 = 1 - 2 + 2 = 1.

19. What is triple point?

It is the point at which three phases are in equilibrium



20. State the conditions under which two substances can form a simple eutectic.

- They must be completely miscible in the liquid state, but completely immiscible in the solid state.
- They do not react chemically.

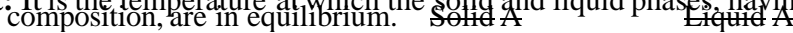
21. What is a metastable equilibrium in water system?

Sometimes water can be cooled below 0°C without the formation of ice known as super cooled

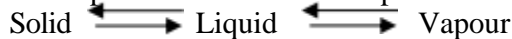
water or metastable equilibrium. Super cooled water \rightleftharpoons Vapour

22. Differentiate melting point, eutectic point and triple point?

Melting point: It is the temperature at which the solid and liquid phases, having the same composition, are in equilibrium.



Triple point: It is the temperature at which three phases are in equilibrium.



Eutectic point: It is the temperature at which two solid and a liquid phase are in equilibrium.



23. What are the types of phase diagrams?

- (i) P-T diagram - If the phase diagram is plotted between temperature against pressure, the diagram is called P-T diagram. It is used for one component system.
- (ii) T-C diagram- If the phase diagram is drawn between temperature against composition, the diagram is called T-C diagram. It is used for two-component system.

24. What is phase diagram? What is the use of studying such diagrams?

Phase diagram is a graph obtained by plotting one degree of freedom against another.

Uses: It is possible to predict from the phase diagrams whether the eutectic alloy or a solid solution is formed on cooling a homogeneous liquid containing mixture of two metals.

25. Mention the merits of phase rule. (or) Mention the applications of phase rule.

- i. It is applicable to both physical and chemical equilibrium
- ii. It is convenient method of classifying the equilibrium states in terms of phases components and degree of freedom.
- iii. It helps in deciding whether the given number of substances remains in equilibrium or not.

26. What are the limitations of phase rule?

- i. Phase rule can be applied only for the system in equilibrium.
- ii. Only three variables like P,T & C are considered, but not electrical, magnetic and gravitational forces.
- iii. All the phases of the system must be present under the same conditions of pressure and temperature.
- iv. Solid and liquid phases must not be in finely divided state, otherwise deviations occur.

PART B

1. Define alloy and discuss the functions and effect of alloying of metals with examples.
2. What are the purposes of alloy making? Illustrate with suitable examples.
3. How are the properties of metals improve by alloy formation? (May 2015, Dec 2015 & Jan 2016)
4. Discuss the heat treatment of steel in detail. (or) Write note on heat treatment of steel. (June 2014 & June 2016)
5. Explain about Ferrous alloys (or) Discuss the composition, characteristics and uses of ferrous alloy such as Nichrome . (Dec 2014 & Jan 2015)
6. What is stainless steel and explain its types?
7. State phase rule and explain the terms involved in it. (June 2014)
8. Explain the one-component water system in detail with neat diagram. (or) Draw and explain the phase diagram of water system. (Jan 2014, Dec 201, June 2016 & Jan 2016)
9. Discuss in detail the Lead -Silver system. Briefly write about Pattinson's process. (or)
10. Draw a neat phase diagram and explain the lead-silver system? Briefly write about Pattinson's process. (May 2013, June 2014, Dec 2015, June 2016, Jan 2016).
11. What is condensed phase rule? What is the number of degrees of freedom at eutectic point for a two-component system?

UNIT –IV FUELS AND COMBUSTION PART A

1. What is coal? How is it classified?

Coal is an important primary solid fuel. It has been formed as a result of alteration of vegetable matter under some favourable conditions. The process of this conversion is called coalification or metamorphism of coal.

Various types of coal are

Wood → Peat → Lignite → Bituminous coal → Anthracite

2. Define caking coals and coking coals.

Coals that produce soft and plastic mass at around 400° C that re-solidifies to form a porous solid are called caking coals. Caking coals that produce solid product of useful grade are called coking coals.

3. What is meant by carbonization of coal?

When bituminous coal is heated strongly in the absence of air, the volatile matter escapes out and the mass becomes hard, strong, porous and coherent, which is called metallurgical coke.

This process is called carbonization.

4. What is metallurgical coke? Give the characteristics of metallurgical coke.

When Bituminous coal is heated strongly in the absence of air, the volatile matter escapes out and the mass becomes hard, strong, porous and coherent, which is called metallurgical coke. This process is called carbonization.

Characteristics:

1. Porosity: Coke should be highly porous.
2. Strength: It should have high mechanical strength.
3. Calorific Value: The calorific value of coke should be high.
4. Purity, the moisture, ash, sulphur contents in metallurgical coke should be low.

5. Distinguish between coal and coke.

1. Percentage of fixed carbon and hence the calorific value of coke is high.
2. Percentage of moisture, volatile and ash contents are higher in coal, whereas they are low in coke.

6. Define octane number. How can it be improved?

The percentage by volume of isooctane in the isooctane-heptane mixture that matches the knocking characteristics of the fuel being tested is called the octane number.

Octane number can be improved by adding anti-knock agents like Tetra Ethyl Lead (TEL)

7. Define cetane number. How can it be improved?

Cetane number is defined as, "the percentage of cetane present in a mixture of cetane and α -methyl naphthalene", which matches the fuel under test in ignition property.

8. Why should leaded petrol not be used?

1. Lead oxide deposits on the spark plug and on cylinder wall, which is harmful to engine life.
2. This creates atmospheric pollution.

9. What is compressed natural gas, CNG? Give the composition. Write its CV.

When the natural gas is compressed, it is called compressed natural gas. It is derived from natural gas. Hence, the primary component of CNG is methane. Its calorific value is 12000–14000 K.cal/m³

10. Mention the properties of CNG

- CNG is expected to be less polluting
- It is lighter than air
- CNG requires a much higher ignition temperature of 540°C
- CNG has low inflammability
- It is the cleanest burning fuel because it emits about 70% less CO
- It is less expensive than petrol and diesel

11. How is CNG superior to LPG?

- 1) CNG emits less pollutants than LPG
- 2) CNG is cheaper and cleaner than LPG
- 3) CNG has higher heating rate than LPG
- 4) CNG mixes very easily with air
- 5) CNG does not emit sulphur and nitrogen

12. What is power alcohol?

Ethyl alcohol is an important liquid fuel. When it is used in an internal combustion engine, it is called power alcohol.

13. What is bio-diesel?

Bio-diesel refers to a vegetable oil or animal fat based diesel fuel consisting of long chain alkyl esters.

14. What are the advantages of bio-diesel?

1. Bio-diesel is non-toxic.
2. It emits less smoke.
3. It is biodegradable.
4. The raw materials are renewable.

15. Define calorific values of a fuel.

The calorific value of a fuel is defined as “the total amount of heat liberated, when a unit mass of fuel is burnt completely”.

16. What is ‘gross calorific value’?

It is defined as the total amount of heat liberated when one unit of the fuel is burnt completely and the combustion products are cooled to room temperature.

17. What is meant by ‘net calorific value’?

It is defined as the net heat produced, when a unit quantity of the fuel is completely burnt and the products of combustion are allowed to escape.

18. Distinguish between proximate and ultimate analysis of coal.

S.No	Proximate analysis	Ultimate analysis
1	It involves the determination of weight percentage of moisture, volatile matter, fixed carbon and ash in coal	It involves the determination of weight percentage of carbon, hydrogen, sulphur and oxygen of the pure coal free from moisture and inorganic constituents

2	It gives the approximate composition of the main constituents	It gives the elementary constituents of coal
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19. What is refining of petroleum ?

The process of removing impurities and separating the crude oil into various fractions having different boiling points is called refining of petroleum.

20. Distinguish between petrol and Diesel

S.No.	Petrol	Diesel
1	It is the low boiling fraction of petroleum	It is the high boiling fraction of petroleum
2	Fuel for SI engine	Fuel for CI engine
3	Knocks due to premature ignition	Knocks due to ignition delay
4	Antiknocking is improved through the addition of TEL	Antiknocking is improved by doping with isoamyl nitrate.

21. What are the characteristics of a good fuel?

1. Moderate ignition temperature
2. High specific heat
3. Low smoke and less ash content
4. Inexpensive and readily available

22. How will you improve the antiknock properties?

1. Alcohol has an octane value of about 90 and that of petrol is only 70. Hence, addition of alcohol to petrol increases the octane value of petrol
2. Anti knock agents like TEL can be added to petrol
3. Aromatic phosphates also act as antiknocking agent. This can be added to petrol and it will avoid lead pollution also.

23. What is diesel index number?

The quality of diesel oil is indicated by its diesel index number. It is calculated as,
 Diesel index number = API(Sp.Gr.) x Aniline point in °F/100

24. Define ignition temperature.

The minimum temperature at which the substances ignite and burn smoothly is called ignition temperature.

25. Define explosive range. Give examples.

The range covered by the lower and upper limits of the fuel is known as explosive range of the fuel. Examples: H₂ (6 to 71), CH₄(6 to 13), petrol vapour (2 to 4.5)

26. Define spontaneous ignition temperature.

The lowest temperature at which a substance will ignite itself without the presence of a spark or flame.

PART-B

1. Describe the proximate and ultimate analysis of coal. Mention its significance.
2. How is metallurgical coke manufactured? What are their special properties and uses?
3. What is meant by crude petroleum? Discuss steps involved in refining of crude petroleum.
4. What is knocking of petrol? What are the factors governing it? How is it measured?
5. What is synthetic petrol? How is it manufactured by Bergius process?

6. Define the terms: Octane number and Cetane number. How are they related to chemical composition and molecular structure of fuel?
7. Explain the calculation of minimum quantity of air required for the complete combustion of a fuel.
8. Write a note on the production, composition and applications of LPG.
9. Calculate the gross and net calorific values of coal having the following compositions, C = 85%, H = 8%, N = 2%, S = 1%, ash = 4 %, latent heat of steam = 587 cal/gm.
10. On analysis, a coal sample has the following composition by weight; C = 85% O = 3%, S = 0.5 % and ash = 3%. Net calorific value was found to be the % of Hydrogen and gross calorific value of coal.
11. What are flue gases? How does Orsat's apparatus analyze them?
12. Explain explosive range of a fuel.
13. Calculate the minimum amount of air needed for the complete combustion of 100 Kgs of coal containing Carbon-80%; Hydrogen-5%; Sulphur- 2%; Oxygen- 2% and the rest nitrogen by weight
14. What is power alcohol? Explain its manufacture, properties of power alcohol.
15. What are the advantages of compressed natural gas?
16. What is leaded and unleaded petrol? Discuss the advantages and disadvantages of leaded petrol?
17. What is meant by diesel-knocking? How is it found? How can it be avoided?
18. Calculate the gross and net calorific values of coal having the following compositions, C = 86%, H = 3.5%, N = 0.6%, S = 1.5%, O = 8.4 %, latent heat of steam = 587 cal/gm.
19. What is bio-diesel? Explain trans-esterification and advantages of bio-diesel.

**UNIT V ENERGY SOURCES AND STORAGE DEVICES
PART-A**

1. Define nuclear fission.

Nuclear fission is defined as “the process of splitting of heavier nucleus into two (or) more smaller nuclei with simultaneous liberation of large amount of energy.

2. What is a moderator? Give example.

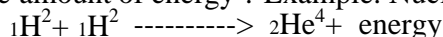
Moderator is the one, which slows down the speed of neutrons in the nuclear reactors. Example: Water, Heavy water & Solid graphite.

3. Mention few important characteristics of nuclear fission.

1. A heavy nucleus U^{235} (or) Pu^{239} , when bombarded by slow moving neutrons, split into two or more nuclei
2. Large quantities of energy are produced as a result of conversion of small mass of nucleus into energy.
3. Two or more neutrons are produced by fission of each nucleus.

4. Define nuclear fusion.

“The process of combination of lighter nuclei into heavier nuclei, with simultaneous liberation of large amount of energy”. Example: Nuclear fusion reaction



5. What is lead-acid accumulator?

A secondary cell consisting of lead electrodes, the positive one covered with PbO_2 , dipping into H_2SO_4 solution. Its EMF is about 2V.

6. Give any two differences between nuclear fission and fusion.

S.No	Nuclear fission	Nuclear fusion
1	It is the process of breaking of a heavier nucleus.	It is the process of combination of lighter nuclei.
2	It emits radioactive rays.	It does not emit any kind of radioactive rays.
3	It occurs at ordinary temperature.	It occurs at high temperature (10^6 K)

7. What is super critical mass and sub-critical mass?

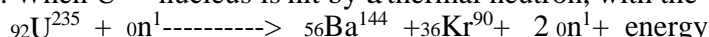
Super critical mass: If the mass of fissionable material (U^{235}) is more than the critical mass. It is called super critical mass.

Sub-critical mass: If the mass of the fissionable material is smaller than the critical mass, it is called sub-critical mass.

8. What is nuclear energy? Give example.

It is the energy released when the nuclei of certain atoms undergo nuclear reaction is called nuclear energy.

Example: When U^{235} nucleus is hit by a thermal neutron, with the release of energy.



What are the drawbacks of nuclear energy?

Nuclear reactor generates large amounts of deadly radioactive waste.

The plant cost is more than estimated and operating cost is high.

10. Give the important requirements for the nuclear chain reaction to occur.

- a) At least one neutron is generated per fission reaction.
- b) The neutron does not escape without causing any fission.
- c) Non-fission absorption of neutrons by U^{235} and U^{238} is prevented.

11. What is a nuclear reactor?

The arrangement or equipment used to carry out fission reaction under controlled conditions is called a nuclear reactor.

12. What is nuclear chain reaction?

A fission reaction, where the neutrons from the previous step continue to propagate and repeat the reaction is called nuclear chain reaction.

13. What is fissile nucleides and fertile nucleides?

1. The fissionable nucleides such as U^{235} & Pu^{239} are called fissile nucleides.
2. The non-fissionable nucleides such as U^{238} & Th^{232} are called fertile nucleides.

14. What is Breeder reactor?

Breeder reactor is the one, which converts non-fissionable material (U^{238} , Th^{232}) into fissionable material (U^{235} , Pu^{239})

15. Mention any two differences of a nuclear reaction and chemical reaction.

S.No.	Nuclear reaction	Chemical reaction
1	Rapid exothermic reaction	Slow reaction
2	Initiated by neutrons	Initiated by heat or cold

16. What is photo galvanic cell (or) Solar cell?

Photo galvanic cell is the one, which converts the solar energy (energy obtained from the sun) directly into electrical energy. It consists of p-type semiconductor (such as Si doped with B) and n-type semiconductor (such as Si doped with P). They are in close contact with each other.

17. Explain the applications of Solar cells.

1. Solar cells are used in calculators, electronic watches, radios and TVs.
2. Solar cells are superior to other type of cells, because these are non-polluting and eco-friendly.
3. Solar energy can be stored in Ni-Cd batteries and lead-acid batteries.
4. Solar cells can be used to drive vehicles.
5. Solar cells, made of silicon, are used as a source of electricity in space Craft and satellites.

18. What are fuel cells?

Fuel cell is a voltaic cell, which converts the chemical energy of the fuels directly into electricity without combustion. It converts the energy of the fuel directly into electricity. In these cells, the reactants, products and electrolytes pass through the cell.

19. What are the applications of H₂-O₂ fuel cell?

1. H₂-O₂ fuel cells are used as auxiliary energy source in space vehicles, submarines or other military-vehicles.
2. In case of H₂-O₂ fuel cells, the product of water is proved to be a valuable source of fresh water by the astronauts.

20. What is wind energy? How is it obtained?

Moving air is called wind, Energy recovered from the force of the wind is called wind energy. The energy possessed by wind is because of its high speed. The wind energy is harnessed by making use of wind mills.

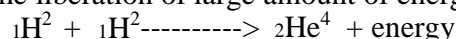
21. What are the drawbacks of wind energy?

Public resists for locating the wind farms in populated areas due to noise generated by the machines and loss of aesthetic appearance.

Wind farms located on the migratory routes of birds will cause hazards.

22. Furnish the sequence of reactions in proton cycle nuclear fusion.

In nuclear fusion reaction, two protons (hydrogen atoms) combine to give a helium atom with the liberation of large amount of energy.



23. What is the important requirement of a battery?

A battery should fulfill the following requirements

1. It should be light and compact for easy transport.
2. It should have long life both when it is being used and when it is not used.

24. What are the advantages of alkaline battery over dry battery?

1. Zinc does not dissolve readily in a basic medium.
2. The life of alkaline battery is longer than the dry battery, because there is no corrosion on Zn.
3. Alkaline battery maintains its voltage, as the current is drawn from it.

25. Will the EMF of battery vary with size? Give reasons for your answer.

Voltage of battery does not vary with size. Since Nernst equation describes the variation of EMF with concentration of the ingredients of the cell only. There is no size factor in the equation.

26. What are secondary cells? Give an example.

Secondary cells are cells in which electrode reactions can be reversed by passing an external electrical energy. They can be recharged. Eg. Lithium battery

27. What are the applications of lithium batteries?

Toys, clocks, digital camera, as a backup batteries in computers, used in communication equipments and also in remote car locks.

28. Lithium battery is the cell of future, Why?

1. Its cell voltage is high, 3V
2. Since lithium is a light weight metals, only 7g (1 mole) material is required to produce 1 mole of electrons.
3. Since Lithium has the most negative E^0 value, it generates a higher voltage than other types of cells
4. Since all the constituents of the battery are solids, there is no risk of leakage from the battery

29. What are non-conventional energy sources? Give examples.

These are the energy sources which are renewable and ecologically safe.
Examples: Wind energy, tidal energy, solar energy, geothermal energy.

30. What are the advantages of super capacitors?

1. Super capacitor is an electric double layer capacitor(EDLC).
2. It is a higher capacity capacitor, with capacitance values much higher than other capacitors.
3. They can store 100 times more energy than electrolytic capacitors.

31. Define light water nuclear power plant.

Light water nuclear power plant is the one, in which U_{235} fuel rods are submerged in water. Here, water acts as both moderator and coolant.

PART-B

1. Distinguish between nuclear fission and fusion reactions.
2. Write a short note on nuclear fission and fusion (or) With a neat sketch explain the functioning of nuclear fission and fusion.
3. Describe briefly controlled nuclear fission as source of useful energy.
4. What is a nuclear reactor? Describe the components of a light water nuclear power plant with a suitable block diagram.
5. Define mass defect and binding energy. How are they related?
6. What are nuclear chain reactions? Explain how to improve the amount of nuclear energy with illustration.
7. What is breeder reactor? Explain with an example.
8. What is primary battery? Write a note on dry cell.
9. Write a brief note on lithium battery.
10. What are lead accumulators? Explain the construction and functioning of a lead accumulator?
11. What are solar cells? Explain with an example. (or) State the principle and application of solar batteries.
12. Describe the construction and working of H_2-O_2 fuel cell (or) What are fuel cells? Explain the construction and working of fuel cells.
13. What is a photovoltaic cell? Explain the construction and working of a photovoltaic cell with a diagram.
14. How is wind energy harnessed? What are its advantages and limitations?
15. How are super capacitors constructed? Explain the working and applications of super capacitors.