CY3151- ENGINEERING CHEMISTRY
QUESTION BANK (REG – 2021)
UNIT I – WATER AND ITS TREATMENT
PART – A

1. **Write any two disadvantages of hard water in boilers. [April/May 2015]**
   When hard water is used in the boilers for the production of steam, following disadvantages occur.
   (i) Scale and sludge formation (ii) Caustic embrittlement (iii) Boiler corrosion
   (iv) Priming and foaming
2. **Why calgon conditioning is better than phosphate conditioning? [AU May 2016]**
   In calgon conditioning, it forms soluble complex of scale but phosphate conditioning converts scales to sludge which needs periodical disposal. So calgon conditioning is better .
3. **How is the exhausted zeolite regenerated? [AU June 2010]**
   The exhausted zeolite is regenerated by treating with 10% solution of NaCl
   $CaZe + 2NaCl \longrightarrow Na_2Ze + CaCl_2$
   $MgZe + 2NaCl \longrightarrow Na_2Ze + MgCl_2$
4. **Define hardness of water. [AU June 2010, 2009]**
   Hardness of water is the property or characteristics of water which prevents the lathering of soap.
5. **List out the requirements of boiler feed water(AU May 2016)**
   The boiler feed water should be free from permanent and temporary hardness which is responsible for boiler troubles and corrosion. The water should be treated and deionised water should be introduced into boiler.
6. **How does Eriochrome Black-T indicator function as an indicator in EDTA titration? [AU June 2008]**
   EBT reacts with hard water to form wine red colored unstable complex. When this hard water reacts with EDTA, it forms stable complex and EBT is set free and gives steel blue color.
7. **Distinguish hard and soft water. [AU Jan 2013,Feb2012, Dec 2002]**

S.NO	HARD WATER	SOFT WATER
1	Hard water does not produce lather with soap solution	Soft water produces lather with soap solution
2	It give wine red colour with EBT indicator	It does not give wine red colour with EBT indicator

8. **Distinguish between carbonate (temporary) and non carbonate (permanent) hardness of water. [AU May 2009, Jan 2008, May 2001]**

S.NO	Temporary hardness	Permanent hardness
1	This alkaline hardness is due to the presence of bicarbonate ions of Ca and Mg.	. This non alkaline hardness is due to the presence of chloride and sulphate ions of Ca and Mg
2	It can be removed by boiling	It cannot be removed by boiling

9. **Define desalination. What is the principle behind desalination? [AU Jan 2009, June 2007, Dec 2006]**
   The process of removing common salt from the water is known as desalination. If a hydrostatic pressure in excess of osmotic pressure is applied on the higher concentrated side, the solvent flows from higher concentration to lower concentration. This process is called reverse osmosis.
10. **Every soft water is not a demineralised water whereas every demineralised water is a soft water- Justify.[AU Jan 2013]**
    Soft water produce by lime soda and zeolite process does not contain hardness producing calcium and magnesium ions but it will contain other ions like Na^+, K^+, $SO4^{2-}$, Cl^- etc on the other hand demineralized water does not contain both anions and cations.
11. **What is meant by calgon conditioning? [Nov/Dec 2015, AU Jan 2013,2009.June 2005]**
    Calgon is sodium hexa meta phosphate $Na_2[Na_4(PO_3)_6]$. This substance interacts with calcium ions forming a highly soluble complex and thus prevents the precipitation of scale forming salts.
    $2CaSO_4 + Na_2[Na_4(PO_3)_6] \longrightarrow Na_2[Ca_2(PO_3)_6] + 2Na_2SO_4$
12. **Name the salts responsible for scale and sludge.**
    Scale – Calcium bicarbonate, Calcium sulphate, Magnesium chloride.
    Sludge- Magnesium chloride, Magnesium carbonate, Magnesium sulphate and calcium chloride
13. **Distinguish between sludge and scale. [AU May 2009]**

S.No.	Sludge	Scale
1	It is a soft, loose and slimy precipitate	It is a hard and adherent coating
2	It is due to the presence of Magnesium chloride, Magnesium carbonate, Magnesium sulphate and calcium chloride	It is due to the presence of Calcium bicarbonate, Calcium sulphate, Magnesium chloride.

14. **What are the salts responsible for carbonate and non carbonate hardness of water? [AU May 2008]**
    Carbonate hardness is due to the presence of bicarbonates of calcium and magnesium. Non Carbonate hardness is due to the presence of chlorides and sulphates of calcium and magnesium.
15. **What is meant by caustic embrittlement? How is it prevented? [Nov/Dec 2015]**
    Caustic embrittlement means intercrystalline cracking of the boiler material.
    Prevention- 1) Using sodium phosphate as softening agent instead of sodium carbonate. 2) By adding tannin, lignin to the boiler water, which blocks the hair cracks.
16. **Mention any two compounds that cause caustic embrittlement in boilers. [April/ May 2015]**
    The compounds causing caustic embrittlement are
    (i) Sodium carbonate (ii) Sodium hydroxide (iii) Sodium ferroate
17. **Mention any two advantages of zeolite process.**
    Water obtained by this process will have only hardness of 1-2 ppm.2) This method is easy and cheap because the regenerated can be used again. 3) Equipment is compact 4) No sludge is formed during the process.
18. **What are ion exchange resins? [AU June2010]**

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

19. How is exhausted resin generated in ion exchange process? [AU Feb 2010]

The exhausted cation exchange column can be regenerated by passing a solution of dilute acids. The exhausted anion exchange column is regenerated by passing a solution of dilute NaOH.

20. What is reverse osmosis? [April/May 2015]

If a hydrostatic pressure in excess of osmotic pressure is applied on the higher concentration side, the solvent flow is reversed. This process is called reverse osmosis.

21. What are boiler compounds? Give examples.[April/May 2015]

Scale forming substances can be removed by adding chemicals directly to the boiler. These chemicals are called boiled compounds. Examples: Sodium carbonate and sodium phosphate.

$CaSO_4 + Na_2CO_3 \longrightarrow CaCO_3 + Na_2SO_4$

$3CaSO_4 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3Na_2SO_4$

22. Mention some methods of converting brackish water into fresh water.

Brackish water can be converted into fresh water through desalination process. Desalination is carried out either by reverse osmosis or electro dialysis.

23. What is meant by priming and foaming? How can theybe prevented. *(A.U Oct. 98)*

Priming 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 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.

24. How is priming and foaming caused? [AU Jan 2011]

Priming is caused by

(i) High steam velocity (ii) Very high water level in the boiler

(iii) Sudden boiling of water (iv)Very poor boiler design

Foaming is caused by

(i) Presence of oil, grease (ii) Presence of finely divided particles

25. Define softening or conditioning of water.

The process of removing hardness producing salts from water is known as softening (or) conditioning of water. Softening of water can be done in two methods

1. External treatment 2. Internal treatment

26. Distinguish between external and internal conditioning of water. [Nov/Dec 2015]

S.No.	Internal Conditioning	External Conditioning
1	It removes scale forming impurities in the form of sludges and converts them into compounds that can be dissolved in water.	It involves the removal of hardness producing salts from the water before feeding it into the boiler.
2	The internal treatment can be done by adding a proper chemical to the boiler water.	The external treatment can be done by zeolite or demineralization process

27. Distinguish between soft water and demineralised water. [AU Jan 2013]

The soft water, produced by lime-soda and zeolite processes, does not contain hardness producing Ca and Mg ions, but it will contain other ions like Na, K, Sulphate , chloride ions. On the other hand demineralised water does not contain both anions and cations.

28. Mention the advantages and disadvantages of demineralization process.

Advantages

(i) Highly acidic or alkaline water can be treated by this process

(ii) The water obtained by this process will have very low hardness (nearly 2 ppm)

29. Write short notes on phosphate conditioning. [AU Feb 2010, May 2008]

Scale formation can be avoided by adding sodium phosphate. It is used in high pressure boilers. The phosphate reacts with Ca2+ and Mg2+ salts to give soft sludge of calcium & magnesium phosphates.

$3\ CaSO_4 + 2Na_3PO_4 \longrightarrow Ca_3(PO_4)_2 + 3Na_2SO_4$

30. How can we remove dissolved oxygen and carbon-dioxide from hard water?

Sodium sulphite and hydrazine is used for removing dissolved oxygen.

$2Na_2SO_3 + O_2 \longrightarrow 2Na_2SO_4$

$N_2H_4 + O_2 \longrightarrow N_2 + H_2O$

Dissolved oxygen can also be removed from water by mechanical de-aeration.

Dissolved carbon dioxide can be removed from water by adding NH4OH into water.

$2NH_4OH + CO_2 \longrightarrow (NH_4)_2CO_3 + H_2O$

Carbon dioxide along with oxygen can also be removed mechanically by de-aeration method.

***31.* Define Taste and Odour.**

Taste

Taste is the sensation of flavour perceived in the mouth and throat on contact with a s u bstance.

Odour

Odour is a smell (or) scent caused by one (or) more volatilized chemical compounds that are generally found in low concentration.

32. **What is meant by turbidity?**

Turbidity is the reduction of clarity of natural water dueto the presence of finely divided, insoluble impurities suspended in water.

33. **What is the significance of pH in water?**

(i) pH determines the solubility (amount that can be dissolved in water).

(ii) It also determines the biological availability (amount that can be utilized by aquatic life).

(iii) A rise (or) fall in pH can indicate chemical pollution (or) acid rain. Many animals cannot live in water at a pH level below 5 (or) above 9.

34. **Define hardness.**

Hardness is the property (or) characteristics of water, which does not produce lather with soap.

35. **What is BOD? (**APRIL/MAY 2023)

BOD is defined as, "the amount of free oxygen required by bacteria for the biological oxidation of the organic matter under aerobic conditions at 20□C for a period of 5 days".

36. **What is the significance of BOD.**(APJAKTU, Jan 2016, APRIL/MAY 2023)

(i) It indicates the amount of decomposable organic matter present in the sewage.

(ii) It enables us to determine the degree of pollution at any time in the sewage stream.

(iii) Lesser the BOD, better is the quality of water. ie. thewater sample with BOD of less than 3 ppm is considered as pure water, whereas the water more than 4 ppm isconsidered as polluted water.

37. **Define COD.**

COD is defined as, "the measure of amount of oxygen required to chemically oxidise all the oxidisable impurities present in the sewage using an oxidising agent like acidified $K_2Cr_2O_7$".

38. **What are the advantages of COD.**

(i) Determination of COD is carried out only in 3 hours,but determination of BOD is carried out after 5 days.

(ii)It measures both the biologically oxidisable and biologically inert organic matter.

39. ***What is chlorination.***

The process of adding chlorine to water is calledchlorination. Chlorination can be done by the following methods.

By adding chlorine gas

By adding chloramine

By adding bleaching powder

40. ***What is sterilisation.***

The process of destroying the harmful bacterias is known as sterilisation or disinfection. The chemicals used for this purpose are called disinfectants.

41. ***What is break-point chlorination? Explain***

Break point chlorination is the point at which all the impurities are removed and free chlorine begins to appear.

42. ***What is blow-down operation?***

Blow-down operation is a process of removing a portion of concentrated water by fresh water frequently from the boiler during steam production.

43. ***Name the method which separate both ionic and non-ionic impurities from water.****[A.U. Nov.96]*

Reverse osmosis process.

44. ***Name some of the membranes employed in reverse osmosis process. State the advantages of this process. [A.U. Dec.97]***

Example: Cellulose acetate, cellulose butrate.

Advantages (i) It removes ionic as well as non-ionic, colloidalimpurities.
(ii) The life time of the membrane is high and it canbe replaced within few minutes.

45. ***What are the advantages of reverse osmosis method.***

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

46. ***Why is water softened before using in boiler?*** *(A.U. June 2007, May 2017)*

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

1. Scale and sludge formation.
2. Priming and foaming (carry over).
3. Caustic embrittlement.
4. Boiler corrosion.

47. ***What are scales and sludges?*** *(TNV AU May 2009)*

1. Sludge

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

2. Scale

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

48. **Mention any two disadvantages of formation of deposits in steam boilers** (A.U. Dec 2015) What are the disadvantages of scale formation? *(Chen. A.U. June 2009)*

Scales act as thermal insulators. It decreases the efficiency of boiler. Any crack developed on the scale, leads to explosion.

49. ***List two disadvantages of using hard water in boilers.***

1. Scale and sludge formation
2. Priming and foaming (carry over)
3. Caustic embrittlement
4. Boiler corrosion

50. **Mention any two compounds that cause causticembrittlement in boilers.** *(AU June 2014)*

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

51. ***What is meant by caustic embrittlement? How is itprevented.*** *(A.U.June 2007, AU Dec 2009, Jan 2010, Dec 2015, May 2016)*

Caustic embrittlement means intercrystalline cracking ofboiler metal.

Prevention

Caustic embrittlement can be prevented by

a. using sodium phosphate as softening agent insteadof sodium carbonate.

b. by adding tannin, lignin to the boiler water, whichblocks the hair cracks.

52. ***Indicate the reasons for boiler corrosion*** *(Coim. A.U. 2008)*

Boiler corrosion arises due to the presence of

a. dissolved oxygen,
b. dissolved carbon dioxide,
c. dissolved salts.

53. ***What are the requisites of drinking and boiler feedwater?*** *[A.U. Nov.2001]*

(i)	Boiler feedwater		Must have zero hardness and free fromdissolved gases like O_2, CO_2.
(ii)	Drinkingwater	(i)	pH of water should be in the range of7.0 □ 8.5.
		(ii)	Total hardness and dissolved solids ofwater should be less than 500 ppm.

54. ***Soft water is not DM water whereas DM water is softwater - Justify.***

(or)

Distinguish between soft water and demineralised water. *(A.U Jan 2013)*

The soft water, produced by lime-soda and zeolite processes, does not contain hardness producing $Ca^{2□}$ and $Mg^{2□}$ ions, but it will contain other ions like $Na^{□}$, $K^{□}$, $SO^{2□}$, $Cl^{□}$ etc., On the other hand D.M. (Demineralised) water does not contain both anions and cations.

55. ***How is exhausted resin regenerated in ion-exchangeprocess.*** *(Coim A.U. Feb 2010)*

When the cation exchange resin is exhausted, it can beregenerated by passing a solution of dil HCl or dil H_2SO_4.

$$RCa + 2HCl \rightarrow RH_2 + CaCl_2$$

$$RNa + HCl \rightarrow RH + NaCl$$

Similarly, when the anion exchange resin is exhausted,it can be regenerated by passing a solution of dil NaOH.

$$R{-}Cl_2 + 2NaOH \rightarrow R{-}(OH)_2 + 2NaCl$$

56. ***Give some examples for cation exchange resin.***
   a. Sulphonated coals.
   b. Sulphonated polystyrene.

57. ***Give some examples for anion exchange resin.***
   a. Cross - linked quaternary ammonium salts.
   b. Urea - formaldehyde resin.

58. ***How is boiler corrosion, due to dissolved oxygen, removed.***

Sodium sulphite, hydrazine are some of the chemicalsused for removing dissolved oxygen from water.

$$2Na_2SO_3 + O_2 \rightarrow 2Na_2SO_4$$

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

59. ***Name the gases dissolved in water that cause corrosion?***

(i) Dissolved oxygen (DO)

DO in water attacks the boiler material at highertemperature.

$$4Fe + 6H_2O + 3O_2 \rightarrow 4Fe(OH)_3$$

(ii) Dissolved carbon dioxide

Dissolved CO_2 in water produces carbonic acid, whichis acidic and corrosive in nature.

$$CO_2 + H_2O \text{ -------> } H_2CO_3$$

60. ***How does carbon dioxide cause boiler corrosion.***

Dissolved carbon dioxide in water produces carbonicacid, which is acidic and corrosive in nature.

$$CO_2 + H_2O \text{ -------> } H_2CO_3$$

Carbon dioxide gas is also produced from the decomposition of bicarbonate salts present in water.

$$Ca(HCO_3)_2 \text{ -------> } CaCO_3 + H_2O + CO_2$$

61. ***What are ion exchange resins?*** *(AUT TNU June 2010)*

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

62. ***What are the disadvantages of ion-exchange process.***
   a. Water containing turbidity, Fe and Mn cannot be treated, because turbidity reduces the output and Fe, Mn form stable compound with the resin.
   b. The equipment is costly and more expensive chemicals are needed.

63. ***How is water demineralised in an ion-exchanger?***
[A.U Nov.2001]

When the water containing ions (both anion and cation)are passed through ion exchange columns, it absorbs all the ions (anions and cations) as shown below.

Cation exchanger: $R+H+_2 + CaCl_2$ ------->RCa + 2HCl.

Anion exchanger: $R+OH+_2 + 2HCl$ -------> $RCl_2 + 2H_2O$.

64. ***What is meant by internal conditioning of water.***
(A.U May 2014)

Internal conditioning is the process which involves the removal of scale forming substance by adding chemicals directly into the boiler.

65. ***Explain the function of a coagulant with example.***

When the coagulant is added to water, it gets hydrolysed to form a gelatinous precipitate of coagulatant $Al□OH□_3$. The gelatinous precipitate, $Al□OH□_3$, entraps the finely divided and colloidal impurities, settles to the bottom and can be removed easily.

66. ***What are boiler compounds? Mention two different boiler compounds and their actions.***
[May 2001, May 2015]

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

Examples: Sodium carbonate and sodium phosphate.

a. $CaSO_4 + Na_2CO_3$ -------> $CaCO_3 + Na_2SO_4$.

(ii) $3CaSO_4 + 2Na_3PO_4$ -------> $Ca_3 + PO_4+_2 + 3Na_2SO_4$.

67. ***What is calgon conditioning? How is it functioning inwater treatment?***
(TCY AU July 2008)(Chen A.U. June 2005, Jan 2010) (or)
Write the chemical reaction involved in calgon conditioning. *(AU June 2014)*

Calgon is sodim hexa meta phosphate Na_2 [Na_4 $+PO_3+_6$]. This substance interacts with calcium ions forming a highly soluble complex and thus prevents the precipation of scale forming salt.

$2\ CaSO_4 + Na_2$ [Na_4 $+PO_3+_6$] ------->Na_2 [Ca_2 $+PO_3+_6$] + $2Na_2SO_4$

68. ***Why calgon conditioning is better than phosphate conditioning?****(A.U. June 2016)*

In calgon conditioning calgon forms highly soluble complex, but in phosphate conditioning, it gives sludge. So periodical disposal of sludge is important in phosphate conditioning, but in calgon conditioning no problem of disposal.

PART- B

1. What are sludge and scale in boilers? How are they formed? Suggest any two methods to prevent their formation. [April/May 2015]
2. Explain the caustic embrittlement in detail. [Nov/Dec 2015]
3. What is meant by boiler corrosion? How can it be minimized? [Nov/Dec 2015]
4. What is reverse osmosis? How is it useful for desalination of brackish water? Explain with a diagram. [April/May 2015, [Nov/Dec 2015], May 2016, APRIL/MAY 2023]
5. Discuss the process of demineralization of water using ion exchange resins. [AU June 2010, June 2012 April/May 2013, May 2016, APRIL/MAY 2023]
6. What are zeolites? How do they function in removing the hardness of water? [April/May 2015, Nov/Dec 2015, May 2016]
7. What is meant by internal conditioning of water? Explain 1) Colloidal conditioning 2) Carbonate conditioning with relevant equations. [April/May 2015, May 2016]
8. What is reverse osmosis? How is it useful for desalination of brackish water? Explain with a diagram. [April/May 2015, [Nov/Dec 2015]
9. Explain Calgon conditioning in detail. [Nov/Dec 2015, May 2016]
10. Define and explain the significance of the following :
    i) Turbidity ii)Hardness iii) pH
11. What is meant by disinfection? How is it carried out? Explain in detail about the Break Point Chlorination.

UNIT– II – NANOCHEMISTRY
PART-A

1. What are nonoparticles?

Nanoparticles are the particles, the size of which ranges from 1-100 nm.

2. What are nano-materials?

Nanomaterials are the materials having components with size less than 100 nm at least in one dimension.

3. ***What is nano-chemistry?*** *(A.U.T. (Coim) May 2011)*

Nano-chemistry is the branch of nano-science, which deals with the chemical applications of nanomaterials. It also includes the study of synthesis and characterisation of nanomaterials.

4. Distinguish between bulk particles and nano-particles.

(A.U. (CEG) Dec. 2012 June 2013)

Nano-particles	Bulk particles
1. Size is less than 100 nm	Size is larger in micron size
2. Collection of fewmolecules	Collection of thousands of molecules.
3. Surface area is more	Surface area is less
4. Strength, hardness aremore	Strength, hardness are less

5. Name some important physical methods of synthesizing nano-materials.

a. Laser ablation
b. Chemical Vapour Deposition (CVD)
c. Electro-deposition

6. What is CVD?

CVD is Chemical Vapour Deposition. It is a process of chemically reacting a volatile compound of a material with other gases, to produce a non-volatile solid that deposits automatically on a suitably placed substrate.

7. ***What is the basic principle involved in solvothermal synthesis of nano-materials.***

Solvothermal synthesis involves the use of solvent under high temperature (between 100□C to 1000□C) and moderate to high pressure (1 atm to 10,000 atm) that facilitate the interaction of precursors during synthesis.

8. Define nano-wires.

Nano-wire is a material having an aspect ratio ie., lengthto width ratio greater than 20. Nano-wires are also referred toas "quantum wires".

9. What are the characteristics of nano-wires.

a. Nano-wires are two-dimensional material.
b. Conductivity of a nano-wire is less than that of the corresponding bulk materials.
c. It exhibits distinct optical, chemical, thermal and electrical properties due to this large surface area.

10. Mention some important applications of nano-wires.

a. Nanowires are used for enhancing mechanical properties of composites.
b. It is also used to prepare active electronic components such as *p*□*n* junction and logic gates.
c. Semiconductor nanowire crossings are expected to play a important role in future of digital computing.

11. What is nano-Rod?

Nanorod is two dimensional cylindrical solid material having an aspect ratio i.e., length to width ratio less than 20.

12. ***What are nanoclusters?*** *(A.U. (CEG) Dec 2012,* APRIL/MAY 2023*)*

Nanoclusters are fine aggregates of atoms or molecules. The size of which ranges from 0.1 to 10 nm. Of all the nano materials, nanoclusters are the smallest sized nano materials because of their close packing arrangement of atoms.

13. What is magic number

It is the number of atoms in the clusters of criticle sizes with higher stability.

14. What are carbon nano-tubes.

Carbon nanotube is a tubular form of carbon with 1-3nm diameter and a length of few nm to microns.

15. Mentin some uses of CNTs.

a. It is used in battery technology and in industriesas catalyst.
b. It is also used as light weight shielding materialsfor protecting electronic equipments.
c. CNTs are used effectively inside the body fordrug delivery.
d. It is used in composites, ICs.

16. Mention some characteristic properties of nanomaterials. (Chen. A.U Jan 2010)

a. Nanomaterials are very strong and withstandextreme strain and tension.
b. It possesses very good electrical properties andthermal conductivity.

17. ***List any four nano-materials.*** *(Coim. A.U Feb 2010)*

a. Carbon nanotubes.
b. Nanowire.
c. Qauntum dots.
d. Dendrimers.

PART – B

1. Explain the size dependent properties of nano- materials.(AU [CEG] Dec 2012, June 2014)
2. Write an informative note on the properties of nano- materials (AU [CEG] June 2013)

OR

Discuss any four salient properties of nano- materials

3. Discuss the laser ablation and CVD techniques for the sysnthesis of nano- materials. (AU [CEG] June 2013, Jan 2015, APRIL/MAY 2023).
4. What are nano- materials? Write any four methods of preparation of nano- materials. (AU [CEG] Dec2011)

OR

Discuss various types of synthesis involved in the preparation of nano materials. (AU Jan 2014,June 2014)

5. Explain the preparation of nano materials by i) Sol Gel Process ii)Electro spinning (APRIL/MAY 2023)
6. Define the terms : nanorods, nanotubes, nanowires, and nanoclusters. (AU [CEG] June 2013)
7. What are nanomaterials? Discuss the types of Carbon nanotubes and their applications. (AU June 2012)
8. How are carbon nanotubes synthesized? What are its applications? (AU [CEG] Dec 2011, AU Jan 2014 Jan 2015).
9. Explain (a) nanocluster (b) nanowire with examples. (AU Jan 2014)
10. Discuss the solvothermal and laser ablation methods of synthesis of nanomaterials. (AU May 2015)
11. Compare the properties of molecules, nanoparticles and bulk materials. (AU May 2015)

O

Distinguish of molecules, nanoparticles and bulk materials. (AU Jan2014)

12. Write short notes on : i) Carbon nanotubes ii) Nanorods iii) Nanowires (AU Dec 2015)
13. Explain briefly the applications of nanomaterials (A.U.T [TVN] Jan 2009)

OR

Explain any six applications of nanomaterials in various fields. (A.U.May 2014)

UNIT– III –PHASE RULE & COMPOSITES

PHASE RULE

PART-A

1. State phase rule and explain the terms involved.

If 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 degrees of freedom (F) of the system is related to number of components (C) and the number of phases (P) by the following phase rule relation F = C – P + 2

2. What are degrees of freedom (F)?

Degrees of freedom (F) is defined as, "the minimum number of independent variable factors such as temperature, pressure and concentration, which must be fixed in order to define the system completely".

3. Define phase (P) with suitable example.

(Chen A.U. Dec 2009)

Phase is defined as, "any homogeneous physically distinct and mechanically separable portion of a system whichis separated from other parts of the system by definiteboundaries".

Consider a water system consisting of three phases. Ice+s+ ⇌ Water+l+ ⇌ Vapour+g+

Each phase is physically distinct and homogeneous and there are definite boundaries between phases. So this forms three phases.

4. Mention the merits of phase rule.

I. It is applicable to both physical and chemical equilibrium
II. It is a convenient method of classifying the equilibrium states in terms of phases, components, and degree of freedom.
III. It helps in deciding whether the given numbers of substances remain in equilibrium or not.

5. What are the limitations of phase rule?

I. Phase rule can be applied only for the systems in equilibria.
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 T and P.
IV. Solid and liquid phases must not be in finely divided state, otherwise deviations occur.

6. What is eutectic mixture? (OR) Eutectic is a mixture and not a compound explain.

Eutectic mixture is an unique mixture of two solids which has the lowest melting point. Since it is completely immiscible in the solid state, it is a mixture not a compound

7. What is an Eutectic point in a binary alloy system?

It is the point at which two solids and one liquid phase are in equilibrium in a binary alloysystem.

Solid (A) ↔ Solid (B) ↔ Liquid melt (A +B)

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

$CaCO_3(s) \leftrightarrow CaO(s) + CO_2(g)$

It consists of two solid phases and one gaseous phase. P = 2; C = 2

F = C – P + 2 = 2 – 3 + 2 = 1.

9. Give the percentage composition of Bronze.

Bronze is also a copper alloy containing copper and tin in the following composition:
Cu = 80 – 95 %, Sn = 20 – 5%

10. State the number of degrees of freedom for the following system:

Ans: $PCl_5(s) \leftrightarrow PCl_3(g) + Cl_2(g)$ at 50^oC F = C – P + 1; 2 – 2 + 2; F = 2

$CaCO_3(s) \leftrightarrow CaO(s) + CO_2(g)$ C – P + 1; 2 – 3 + 2; F = 1

11. State condensed or reduced phase rule. (Jan 2014, May 2015, APRIL/MAY 2023**)**

Ans: A 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 a condensed system. Since the pressure is kept constant, the phase rule becomes

F' = C – P + 1.This equation is called reduced phase rule or condensed phase rule.

12. What is meant by phase diagram?

Phase diagram is a graph obtained by plotting one degree of freedom against the other. It is possible to predict from the phase diagrams whether an eutectic alloy or a solid solution is formed on cooling a homogeneous liquid containing mixture of two metals.

13.What is triple point? (June 2014)

It is the temperature at which three phases (solid, liquid, vapour) are in equilibrium.

Solid ↔ Liquid ↔ Vapour

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

$CuSO_4(s) + 5H_2O(l) \leftrightarrow CuSO_4.5H_2O(s)$ Number of phases = 3 Number of components = 2

15.What is metastable equilibrium?

Sometimes water can be cooled below 0°C without the formation of ice, this water is known as super-cooled water. The equilibrium between super-cool water and the vapour is known as metastable equilibrium

16. Calculate the number of components and degree of freedom for the following equilibrium.

$NH_4Cl(s) \leftrightarrow NH_3(g) + HCl(g)$ Ans: This system consists of two phases and one component.
P = 2; C = 1; F = C – P + 2 = 1 – 2 + 2 = 1

17. A system consists of benzene and water. Give the number of phases?

Two liquid phases and one vapour phase

18. Calculate the number of phases present in the following systems.

$MgCO_3(s) \leftrightarrow MgO(s) + CO_2(g)$ Ans: = 3 phases

Rhombic sulphur(s) ↔ Monoclinc sulphur(s) Ans:= 2 phases

Ice(s) ↔ Water(l) ↔ water vaour(g) Ans:= 3 phases

An emulsion of oil in water Ans: = 2 phases

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

(i) They must be completely miscible in the liquid state but completely immiscible in the solid state. (ii) They should not chemically react with each other.

20. Calculate the number of phases and components present in the following reaction.

i) $MgCO_3(s) \rightarrow MgO(s) + CO_2(g)$

3 phases – Solid Mg CO_3, Solid MgO & Gaseous CO_2 Components – 2

ii) $NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$ 2 Phases & 1 Component

21. Define component with suitable example.(Chen A.U. Dec 2009, Dec 2015, Jan. 2018)

Component is defined as, "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".

Consider a water system consisting of three phases.

Ice+s+ $\rightleftharpoons$ Water+l $\rightleftharpoons$ Vapour+g

The chemical composition of all the three phases is H_2O, but are in different physical form. Hence the number of component is one.

22. Calculate the number of phases present in the followingsystems.(Coim. A.U. July 2009)(A.U. June 2007, Dec 2016)

(a) $MgCO_3$ +s+ $\rightleftharpoons$ MgO+s+ CO_2 +g------->Three phases.

(b) Rhombic sulphur+s+ $\rightleftharpoons$ Monoclinic sulphur+s+ Two phases.

(c) Ice+s+ $\rightleftharpoons$ water+l+ $\rightleftharpoons$ water vapour+g+ Three phases.

(d) An emulsion of oil in water Two phases

(e) NH_4Cl+s+ $\rightleftharpoons$ NH_3 +g+ HCl+g+Two phases.

21. How many components are present in the system.

KCl + Water + KCl + hydrate *(A.U.T(Coim) July 2010)*

Number of phases + 3 ; Components + 2.

22. 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. P - T diagram 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. T - C diagram is used for two component system.

23. What is the effect of pressure on the melting point ofice?

Melting point of ice decreases with increase of pressure.

24. How many phases and components are existing at triple point in ice - water - water vapour system?

Phases - 3; Components - 1.

25. What is an eutectic alloy?

It is an unique composition of two solids, which has the lowest melting point, when compared to the melting point oftwo solids,

Since, it has the same composition both in the liquid and solid states, it behaves like a pure solid substance.

26. What are the uses (or) significance of eutectic mixture?(A.U. Dec

2008)

1. Suitable alloy composition can be predicted with the help of eutectic systems.
2. Eutectic systems are used in preparing solders, used for joining two metal pieces together.

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

(i). It is applicable to both physical and chemicalequilibria;

(ii). It is convenient method of classifying the equilibrium states interms of phases, components and degreeof freedom.

(iii) It helps in deciding whether the given numberof substances remain in equilibrium or not.

29. Differentiate melting point, eutectic point and triple point.

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

Solid A ⇌ Liquid A

Eutectic point: It is the temperature at which two solids anda liquid phase are in equilibrium.

Solid A □ Solid B ⇌ Liquid

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

Solid ⇌ Liquid ⇌ Vapour

30. What is the degree of freedom at eutectic point inLead-Silver system?

(A.U. Dec 2014)

Degree of freedom is zero ie., F □ 0

31. What is thermal analysis.

Thermal analysis is a method involving a study of the cooling curves of various compositions of a system during solidification. The shapes of the freezing point curves for any system (involving metals) can be determined by thermal analysis. The form of the cooling curve indicates the composition of the solid.

32. How is cooling curve drawn.

A pure substance in the fused state is allowed to cool slowly and the temperature is noted at different time interval. Then graph is plotted between temperature and time

33. What are the important uses of cooling curves.

1. Melting point and eutectic temperature can be noted fromthe cooling curve.
2. Percentage purity of the compounds can be noted fromthe cooling curve.
3. The behaviour of the compounds can be clearlyunderstood from the cooling curve.
4. The composition corresponding to its freezing pointyields the composition of the alloy.
5. The procedure of thermal analysis can be used to derivethe phase diagram of any two component system.

34. What are the uses (applications) of phase diagrams. (A.U. May 2017, Jan. 2018)

1. It is possible to predict from the phase diagrams whether an eutectic alloy or a solid solution is formed on cooling a homogeneous liquid containing mixture of two metals.
2. The phase diagrams are useful in understanding the properties of

materials in the heterogeneous equilibrium system.

3. The study of low melting eutectic alloys, used in soldering, can be carried out using phase diagrams.

PART –B

1. **What is phase rule? Explain the terms involved in it. (June 2014)**
2. **Explain one component water system with a neat phase diagram? (Jan 2014, May 2015, Dec 2015, Dec 2016)**
3. **Write a note on simple eutectic system with neat diagram (Pb-Ag) system ? (June 2014, May 2015, Dec 2015, Dec 2016)**
4. **Mention the limitations of the Phase Rule.**
5. **What is condensed Phase Rule? What is the number of Degrees of Freedom at the Eutectic Point for a two component system?**
6. **What is thermal analysis? Draw the cooling curves of a pure substance and a mixture and discuss.**
7. **Explain the construction of Phase Diagram with neat sketch.**

COMPOSITES

1. Define a composite.

"A material system consisting a mixture of two (or) more micro-constituents, which are mutually insoluble, differing in form (or) composition and forming distinct phases". Such a combination, possesses properties different from those of any of its constituents.

2. What are the constituents of composites?

Composites consist of two important constituents.

(i) Matrix phase (or) Matrix resin

(ii) Dispersed phase (or) Reinforcement.

3. What is matrix phase?

Matrix phase is the continuous body constituent, which encloses the composite. Matrix phase may be metals, ceramics (or) polymers (liquid resins), composites using these matrix are known as MATRIX Phase.

4. What is cure reaction?

Formation of cross-linking in certain polymers is known as cure reaction.

Cure reactions are done by using a curing agent. These uncross-linked linear polymers contain functional groups (or) double bonds.

5. What is meant by reinforcement?

It is a process of improving the characteristics of the plastic matrix by adding reinforcing agents. The reinforcing agents may be organic (or) inorganic in nature. They may be in the form of powder, flakes, fibres.

6. Write some characteristics of fibre.

(i) Fibre possesses high tensile strength.

(ii) It possesses high stiffness.

(iii) It lowers overall density of composites.

7. What are whiskers. Give examples.

Whiskers are thin strong fibre like material made by growing a crystal.

Example: Graphite, silicon carbide, silicon nitride

8. What are the characteristics of FRP?

1. It possess superior properties like higher yield strength, fracture strength and fatigue life.
2. Since fibre prevents slip and crack propagation, themechanical properties of FRP gets increased.
3. It possess high corrosion resistance and heat resistanceproperty.

9. What are the uses of ceramic matrix composites?

They are used in re-entry thermal shields in spacevehicles and tiles, pump seal, round rings, brake linings etc.

10 What are hybrid composites?

Hybrid composites are new class of materials composed of a suitable polymer matrix reinforced with two different fibres (or) fillers.

10. What are the types of hybrid composites?

Functionally hybrid composites are of three types

1. Structurally hybridized composites
2. Materials hybridized in chemical bond
3. Functionally hybridized composites.

12. Write about the uses of hybrid composites.

1. It is used in light-weight transport (land, water (or) oil)structural components.
2. It is also used in light weight orthopedic componentsand sporting goods.
3. It is used to make furniture like chair, table and bathtubs
4. It is used in railway coach interiors.
5. It is also used in making daily used applications likeplates and spoons.
6. Automobile industry utilizes hybrid composites in manyof the interior and exterior applications.

PART - B

1. **What are Composites ? Explain the constituents of Composites.**
2. **What are the advantages of Polymer Composites? Explain using FRP as an example.(CBE A.U Jan 2009)**
3. **Write a note on FRP. (Chen.A.U. Jan 2009, June 2009, TNV A.U Jan 2009, Coim A.U.Jan 2010)**
   OR
   Write notes on Polymer Matrix Composites. (Coim. A.U. Jan 2010)
4. **What are composites? Give the preparation and uses of glass fiber reinforced composites. (Chen A.U. Jan 2010)**
5. **Write notes on the following: i) Ceramic Matrix Composites** (APRIL/MAY 2023) **ii) Hybrid Composites**

UNIT IV - FUELS AND COMBUSTION

Part – A (2 marks)

1. **What are the drawbacks of sulphur in coal ? (AU 2015)**
   Though it increases the calorific value the oxidation products of sulphur SO_2, SO_3 especially in the presence of moisture forms Sulphuric acid which corrodes the equipment and pollute the environment.

2. **What is meant by knocking and cracking?(AU 2011)**

   Knocking is a kind of explosion due to rapid pressure rise occurring in an internalcombustion engine. Knocking can be reduced by adding Tetra ethyl lead.
   Cracking is defined as decomposition of higher molecular weight hydrocarbons to lowermolecular weight hydrocarbons having low boiling point.
   Eg: cracking of heavy oil.

3. **Define explosive range of fuel. Give examples.(AU 2014)**

   The range covered by the upper and lower limits of the fuel is known as explosive rangeof the fuel.
   Eg. H_2 (6-71), CH_4 (6-13) petrol vapour (2-4.5)

4. **What is Cottrell's process in crude refining?(AU 2009)**

   Removal of water from oil by using ring electrodes is called Cotterll's process.when the crude oil is allowed to flow between the two highly charged electrodes the colloidal water combine to form large drops which is then separated from oil.

5. **What is meant by calorific value of a fuel? What are the types of calorific values?**

   The amount of heat liberated by the complete combustion of a unit mass of a fuel iscalled calorific value. Its unit is calorie or kilocalorie. The two types are Higher or Gross calorific value and Lower or Net calorific value.

6. **Write Dulong's formula for calculation of calorific Value.**GCV= 1/100(8080C+34500(H-O/8)+2240S)k.cal/kg LCV=GCV-0.09H X 587 k.cal/kg.

7. **What is synthetic petrol?(AU 2011)**

   The gasoline obtained from the fractional distillation of crude petroleum oil is called straight run or synthetic petrol. Coal paste mixed with heavy oil and catalyst and heated

under pressure will give crude oil which then fractionate and give gasoline.

8. **Write the hydrocarbon order on the basis of knocking.**
   Straight chain paraffins> Branched chain paraffins> Olefins >Cycloparaffins> Aromatics

9. **What are octane and cetane number?(AU 2006)**

   Octane number is defined as the percentage of iso-octane present in a mixture of iso-octane and n-heptane.
   Cetane number is defined as the percentage of cetane present in a mixture of cetane and α- methyl naphthalene.

10. **What is anti-knocking agent?**

    Knocking can be reduced by adding TEL tetra ethyl lead. This is known as antiknock.To overcome the disadvantage of leaded petrol antiknock fluid mixture of TEL 60%,Ethylene bromide 26%, ethylene chloride 9% and a red dye 2%, can be used.

11. **What is LPG and CNG? Give its composition.(AU 2015)**

    Compressed Natural Gas is an natural gas compressed to a high pressure of about 1000 atmospheres.

S.No	Constitutents	%
1	Methane	85
2	Ethane	8
3	Propane	4
4	Butane	1.5
5	Higher Hydrocarbons	1.5

Its calorific value is 12000-14000kcal/m

Liquefied Petroleum Gas is a byproduct obtained during the cracking of heavy oils or from natural gas. Its calorific value is 28000 kcal/m3

S.No	Constitutents	%
1	n-Butane	30-35
2	IsoButane	30-35
3	Butylene	15-20
4	Propane	20-25
5	Propylene & Ethane	rest

12. Give the difference between caking and coking coal.(AU 2011)

Caking coals are those which on heating in the absence of air becomes soft , plastic and fuse together to large coherent mass.
Coking coals are those which on heating yield residue which isporous, hard, strong and used for metallurgical purposes.

13. Write the expression for the amount of air required for combustion of 1kg fuel.

Theoretical amount of oxygen required for the complete combustion of1kg solid or liquid

fuel is:

={32/12 X C + 8[H-O/8]+S}kg

Since the percentage of oxygen in air by mass is 23, the amount of air required for combustion is

= 100/23{32/12 X C + 8[H-O/8]+S}kg

C= mass of carbon, H= mass of hydrogen, O= mass of oxygen,S= mass of sulphur

14. How is sucrose converted into ethyl alcohol?

The invertase enzyme present in the yeast converts sucrose into glucose and fructose.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{Invertase}} C_6H_{12}O_6 + C_6H_{12}O_6$$

Glucose Fructose

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} 2\,C_2H_5OH + 2CO_2\uparrow$$

15. What are the advantages of compressed natural gas?

i) the octane rating of CNG is high, when compared to petrol.

ii) noise level is much less than diesel.

iii) CNG vehicle limit 40% less of nitrogen oxide,90% less of hydrocarbons, 25% less of CO_2

16. Why is net calorific value is less than gross calorific value?

The lower calorific value or net calorific value which supposes that the products of combustion contain the water of combustion to the vapour state. The heat contained in this water is not recovered. The gross calorific value which supposes that the water of combustion is entirely condensed. The heat contained in this water is recovered.

18. What is the cause of knocking in internal combustion engines? Name a commonly used antiknock?

The **knocking** sound often occurs when the air-fuel mixture is incorrect, which **causes** the fuel to burn in uneven pockets rather than uniform bursts. Left untreated, it can cause damage to the piston and cylinder wall. The commonly used antiknock is tetraethyl lead.

19. What is meant by hydrogenation of coal?(AU 2011)

If coal is heated with hydrogen to high temperature under high pressure, it is converted to gasoline. The preparation of liquid fuel from solid coal is called hydrogenation of coal.

20. Select the compound which possess highest octane number and highest cetane number out of n-heptane, n-hexadecane, n-octane and isooctane.

n-heptane< n-hexadecane < n-octane < isooctane - octane number

isooctane< n-heptane < n-octane < n-hexadecane - cetane number

21. What is meant by combustion of fuels?

Combustion is a process of rapid exothermic oxidation, in which a fuel burns in the presence of oxygen with the evolution of heat and light.

22. Define spontaneous ignition temperature?

It is defined as the minimum temperature at which the fuel catches fire (ignites) spontaneously without external heating.

23. What is ignition temperature?

It is the lowest temperature to which the fuel must beheated.so that it starts burning smoothly.

24. What is power alcohol? Mention the advantage.(AU 2014)

When ethyl alcohol is blended with petrol at a concentration of 5-10%, it is called power alcohol.

1. It is cheaper than petrol
2. If any moisture is present, power alcohol absorbs it.
3. As ethyl alcohol contains oxygen atoms, complete combustion occurs, so emission of CO, hydrocarbon, particulates are reduced.

25. What are the desirable characteristics of metallurgical coke.(AU 2010)

- Purity: The moisture, ash, sulphur, contents in metallurgical coke should be low.
- Porosity: Coke should be highly porous.
- Strength: It should have high mechanical strength.

- Calorific value: The calorific value of coke should be high.

26. What is meant by the term "Fixed carbon".

It is the pure non-volatile, carbon content present in the coal. Higher the percentage of fixed carbon greater is its calorific value.

27. What is biodiesel?

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

28. How is cetane number improved?

Cetane number can be increased by adding certain additives called dopes.Examples : Ethyl nitrate, isoamyl nitrate.

29. What is meant by refining of petroleum?

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

30. Define ultimate analysis?

It involves the determination of weight percentage of carbon, hydrogen, sulphur and oxygen ofthe pure coal, free from moisture and inorganic constituents.

31. What are the important products recovered from otto hoffman's method?

a) Tar b) Ammonia c) naphthalene d) benzene e)H_2S

32.**Define carbon footprint (**APRIL/MAY 2023**).**

It is the total amount of green house gases (including CO_2 and CH4) that are generated (emitted)

by our direct and indirect activities.

33. **Suggest any two methods of reducing carbon emission.**

Carbon emission can be reduced by reducing green house gas emission. It can be done by the following ways.

1.In industry, green house gases can be reduced by many ways.

(i) Including energy efficiency
(ii) Fuel switching
(iii) Combined heat and power
(iv) Use of renewable energy

2.Avoid of using HFC's in refrigeration, air conditioning and foam blowing.

34. **Define carbon emission?**

It is defined as the release of carbon into the atmosphere. Since green house gas emissions are often

calculated as carbon dioxide equivalents, they are often referred to as "carbon emissions".

35. What is the importance of kjeldahl's method.

The determination of nitrogen content is carried out by Kjeldahl's method.

36. Mention the significance of nitrogen content in coal.

(i) Nitrogen does not have any calorific value, and its presence in coal is undesirable.
(ii) Good quality coal should have very little nitrogen content.

Part – B (16 marks)

1.What is meant by proximate analysis of coal? What are the quantities estimated inthis analysis and their significance. ***(A.U APRIL-MAY-2015)***

2.Describe the ultimate analysis of coal***(A.U JUNE-2014)***

3.Differentiate proximate and ultimate analysis of coal. **(JAN-2016)**

4.What is meant by proximate analysis ?***(A.U JUNE 2016)***

5.What is metallurgical coke? How is it superior than coal? Describe any one method of manufacturing metallurgical coke. ***(A.U APRIL-MAY-2015,*** APRIL/MAY 2023***)***

6.Describe the Otto-Hoffman process for preparing coal. **(*A.U DEC 2014/ MAY 2016,*** APRIL/MAY 2023***)***

7.Manufacture of petrol by Bergius process.***(A.U JUNE-2014)***

8.How does reforming of petrol increases the octane number? **(JAN-2016)**

9.Write a note on i) power alcohol ii) Bio-diesel **(*AU JUNE 2014,2017)***

10.Define gross and net calorific values.Calculate gross and net calorific values of coal sample containing 84% carbon , 1.5% sulphur, 6% nitrogen, 5.5% hydrogen and 8.4% oxygen. ***(A.U APRIL-MAY-2015)***

11.Calculate the volume of air required for complete combustion of 1m3 of gaseous fuel having the composition: CO =46%, CH_4 = 10%, H_2 = 4%, C_2H_2 =2% , N_2 1% and the remaining being CO_2. ***(A.U JUNE-2014)***

12. A sample of coal was found to contain the following (C=81% , H=4% , O=2%,N=10%,S=2%) and remaining being ash. Estimate the quantity of minimum air required for the complete combustion of 3m^3 of the sample. . ***(A.U MAY-2017)***

13.Describe the determination of Flue gas analysis and discuss its significance. **(*A.U DEC & JUNE2014/MAY 2016,2017)***

14. What is carbon footprint? Mention any 5 important sources? How to lower carbon footprint?

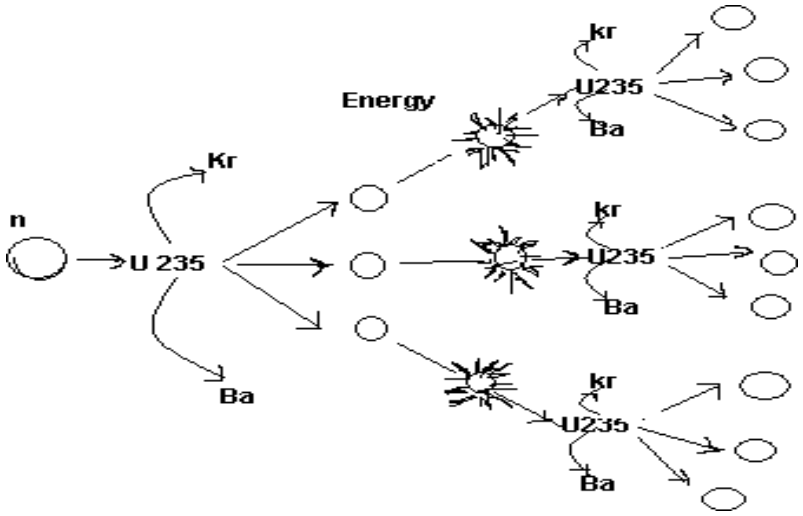
UNIT – V- ENERGY SOURCES AND STORAGE DEVICES

1) Define nuclear fission? (AU Dec 2007, May 2009, May 2015)

Nuclear fission: It is the nuclear reaction in which heavy isotopes are split into lighter nuclei on bombardment by neutrons. Fission reaction of U^{235} is given below

$_{92}U^{235} + _0n^1 \rightarrow {}_{36}Kr^{92} + {}_{56}Ba^{141} + 3\,{}_0n^1 +$ energy

2) Draw a neat fission chain reaction and explain?(AU July 2008, May 2017)



In the nuclear fission reaction, the secondary neutrons emitted from the fission of U^{235} may hit another U^{235} nucleus and cause fission producing more neutrons and so on. Thus, a chain of self sustaining nuclear reaction will set up with the release of enormous amount of energy. This type of reaction is known as a nuclear chain reaction.

3) What is nuclear fusion? (AU June 2007)

Nuclear fusion: Process of combination of lighter nuclei into heavier nucles with simultaneous liberation of large amount of energy. (e.g) solar system

$_1H^2 + {}_1H^2 \rightarrow {}_2He^4 +$ Energy

4) Differentiate between nuclear fission and nuclear fusion? (AU Dec 2014,May 2016)

S.NO	NUCLEAR FISSION	NUCLEAR FUSION
1	It is the process of breaking a heavy nucleus into two or more light fragments	It is the process of fusing two light nuclei into a single nucleus.
2	It emits radioactive rays.	It does not emit radioactive rays.

3	It occurs spontaneously at ordinary temperature.	It occurs at high temperature.
4	It gives rise to chain reaction.	It does not give rise to chain reaction.
5	It emits neutrons.	It emits positrons.
6	It is performed under controlled conditions.	It cannot be controlled.
7	The mass number and atomic number of new elements are lower than that of parent nucleus.	The mass number and atomic number of the product is higher than that of the starting elements.

5) Define nuclear energy? (AU July 2009, June 2014)

Nuclear Energy

- The enormous amount of energy released during the nuclear fission is due to the loss in some mass.
- During nuclear fission, the sum of the masses of the products formed is slightly less than the sum of masses of target species and bombarding neutron.
- The loss in mass gets converted into energy according to Einsteins equation

$E = mc^2$

C = velocity of light

m= loss in mass

E= energy

6) What is light water nuclear power plant?

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

7) Explain the process taking place in light water nuclear power plant?

- The fission reaction is controlled by inserting or removing the control rods of B^{10} automatically from the spaces between the fuel rods.
- The heat emitted by U^{235} in the fuel core is absorbed by the coolant.
- Heat is transferred to sea water and then converted into steam.
- The steam then drives the turbines, generating electricity.

8) What is a breeder reactor? (AU Jan 2009, Jan 2013)

A breeder reactor is a nuclear reactor that converts non-fissonable like U^{238} and Th^{232}material into fissional materials like U^{235} and Pu^{239}.

9) What is a nuclear reactor?

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

10) What are the components of a nuclear reactor?

Fuel rods, control rods, moderator, coolant, pressure vessel, protective shield, and turbine.

11) What are functions of fuel rods and control rods?

Fuel rods: U-235 is used in the reactor in the form of rods or strips. The fission of U-235 produces heat energy and neutrons that start the chain reaction.
Control rods: It controls the rate of fission reaction. These are made of boron or cadmium that absorbs the excess neutrons.

12) What are the functions of moderators?

Moderator: It slows down the speed of the neutrons. The most commonly used moderator is ordinary water, graphite etc.

13) What are the functions of coolant and pressure vessel? (AU June 2011)

Coolant: It cools the fuel core by removing the heat produced by the fission reaction. Water used in the reactor serves both as moderator and coolant.
Pressure vessel: It encloses the core and also provides the entrance and exit passages for coolant.

14) Explain the role of protective shield and turbine?

Protective shield: It protects the operating personnel and environments from destruction in case of leakage of radiation.
Turbine: The steam generated in the heat exchanger is used to operate a steam turbine, which drives a generator to produce electricity.

15) Explain the brief working of power plant?

U-235 or enriched U-235 are used as the fuel. The control rods of boron are inserted or removed automatically in between the fuel rods. The heat emitted by the fission reaction is absorbed by the coolant water. The heated water then goes to the heat exchanger and produces steam. The steam then turns the turbines, generating electricity.

16) Draw the components of a nuclear reactor with a neat diagram?

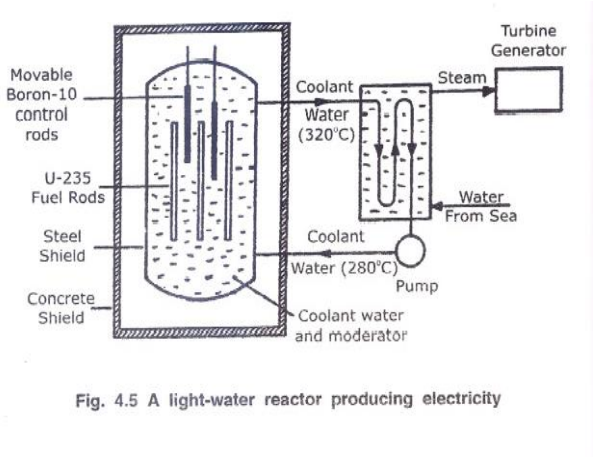


Fig. 4.5 A light-water reactor producing electricity

17) What is a photogalvanic cell?

Photogalvanic cell is the one , ehich converts the solar energy into electrical energy.

18) Explain the principle of solar cell? (APRIL/MAY 2023)

- Solar cells consists of a p-type semiconductor(si with B) and n-type semiconductor (si with P).
- When solar rays fall on the top layer of p-type semiconductor, the electrons from the valence band get promoted to the conduction band and cross the p-n junction into n-type semiconductor.
- Thereby potential difference between two layers is created, which causes flow of electrons

19) What are the uses of solar cell?

Used in calculators, electronic watches, street lights, water pumps to run radios and TVs.

20) What are solar batteries?

- When a large number of solar cells are connected in series it form a solar battery.
- Solar battery produce more electricity which is enough to run water pump, street light etc.

21) What are batteries? Explain secondary batteries.

It is an arrangement of several electrochemical cells connected in series, which can be considered as a store house for electrical energy on demand.

- In these cells, the electrode reactions can be reversed by passing an external energy.
- They can be recharged by passing electric current.

- They are called storage cells or accumulators.
- Ex: Lead acid storage cell, Nickel- cadmium cell.

22) What are alkaline batteries? (AU Feb 2010)

- Here the powdered zinc is mixed with KOH and MnO_2 to get a gel
- A Carbon rod acts as cathode. It is immersed in KOH
- The outside cylindrical body is made up of zinc
- This is an improved form of the dry cell.

23) Write the cell reaction of alkaline battery? (AU June 2007)

At anode : $Zn\ (s) + 2OH^- \rightarrow Zn(OH)_2 + 2e^-$

At cathode: $2MnO_2 + H_2O(l) + 2e^- \rightarrow 2OH^- + Mn_2O_3$

Overall reaction:

$Zn\ (s) + 2MnO_2 + H_2O(l) \rightarrow Zn(OH)_2 + Mn_2O_3$

Uses: It is used in calculators, watches etc.,

24) Write the description of lead acid battery? (Au Jan 2009)

- It consists of number of voltaic cells connected in series.
- Pb is anode and PbO_2 is cathode.
- Number of Pb plates and PbO_2 plates are connected in parallel.
- Plates are separated from adjacent ones by insulators like rubber or glass fiber.
- This arrangement is immersed in dil. H_2SO_4
- Each cell produces a voltage of 2v.

25) Write the cell reactions of lead acid battery? (AU Jan 2008, Jan 2016)

At anode : $Pb\ (s) + SO_4^{2-} \rightarrow PbSO_4\ (s) + 2e^-$

At cathode: $PbO_2(s) + SO_4^{2-} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2\ H_2O$

Overall reaction:

$Pb\ (s) + PbO_2(s) + 2H_2SO_4 \rightarrow PbSO_4 + H_2O + \text{energy}$

26) What are the uses of lead acid battery?

- It is used to supply current mainly in automobiles such as cars. Buses, trucks, etc.,
- It is also used in gas engine ignition, telephone exchanges, hospitals, power stations.

27) Give the description and uses of nickel cadmium battery.

- It consists of a cadmium anode.
- A metal grid containing a paste of NiO_2 acting as a cathode.
- KOH is electrolyte

Uses:

- It is used in calculators. Electronic flash units, transistors and cordless appliances.

28) Write the description and cell reactions of lithium sulphur battery? (AU Jan 2009)

- It consists of a lithium anode and a graphite cathode.
- A solid electrolyte generally β-Alumina is packed in between the electrodes.
- Here sulphur is the electron acceptor.

At anode: $2Li(s) \rightarrow 2Li^+ + 2e^-$

At cathode: $S + 2e^- \rightarrow S^{2-}$

Overall reaction:

$2Li(s) + S \rightarrow 2Li^+ + S^{2-}$

The sulphide ions formed react with elemental sulphur to form the polysulphide ion.

Uses

- It is used in electric cars

29) **Give the cell reactions of nickel cadmium battery?**

At anode: $Cd(s) + 2OH^- \rightarrow Cd(OH)_2(s) + 2e^-$

At cathode: $NiO_2 + 2H_2O(l) + 2e^- \rightarrow 2OH^- + Ni(OH)_2(s) + \text{energy}$

Overall reaction:

$Cd(s) + NiO_2 + 2H_2O(l) \rightarrow Cd(OH)_2(s) + Ni(OH)_2(s) + \text{energy}$

30) Write the description and cell reactions of H2-O2 fuel cell?

It is a voltaic cell which converts chemical energy to electrical energy.

Fuel + oxygen → oxidized products + electricity

Anode – porous electrode, **cathode** – compressed carbon with (pt, pd) as catalyst.

Fuel-hydrogen, **oxidizer** - oxygen, **electrolyte** - 25% KOH or NaOH.

At anode: $2H_2 + 4OH^- \rightarrow 4H_2O + 2e^-$

At cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$

Overall reaction: $2H_2 + O_2 \rightarrow 2H_2O$

EMF of the cell = 0.8 to 1.0 V

31) What are the limitations of H2-O2 fuel cell? (AU May 2015)

As the fuels are gases they have to be stored carefully in big tanks under high pressure.They cannot store electrical energy.

Electrodes are expensive and short lived

.

32) What are the advantages of lithium battery? (AU June 2009)

Cell voltage is high 3V. Lithium being a light weight metal, 7g is required to produce 1mole of electrons. Battery can be made in a variety of sizes and shapes.

33) Define mass defect.

The difference between the calculated and experimental masses of nucleus is called mass defect. It is denoted by Δm.

$\Delta m = \{Total\ mass\ of\ the\ protons, neutrons, and\ electron\}$ – {Experimental mass of the nucleus}

34) What is binding energy?

Binding energy is defined as the energy released when a given number of protons and neutrons coalesee to form nucleus.

35)What are the components of LIB?

- A positive electrode (Layers of lithium-metal oxide) (cathode)
- A negative electrode (Layers of porous carbon) (anode)
- An electrolyte (Polymer gel) (separator)

36) What are the merits of wind energy?

(i) It does not cause any air pollution.
(ii) It is very cheap and economic.
(iii) It is renewable.
(iv) It does not cause any pollution

37) Write any four methods adopted for harnessing wind energy?

(a) Sky sail.
(b) Ladder mill.
(c) Kite ship (Large free flying sails).
(d) Sky wind power (Flying electric generator).
(e) Briza technologies (Hovering wind turbine).
(f) Sequoia automation (The kite wind generator).

38. Name any three highly investigated solar cell materials.

1. Crystalline Si
2. Thin films
3. Next generation Perovskite Solar Cells (PSCs)
4. Define geo-thermal energy.

The energy harnessed from the high temperature present inside the earth is called geothermal energy.

PART B

1) **Explain the components and their functions of nuclear reactor with a neat diagram?Give the working of light water nuclear power plant. (AU June 2009, May 2015, May 2017)**
2) **What is a photovoltaic cell? Explain the principle and working of solar cell with aneat diagram. (AU Jan 2010, Dec 2014, May 2015)**
3) **How is wind energy harnessed? What are its advantages and its limitations?(AU May 2015, Jan 2016, May 2016)**
4) **What are lead accumulators? Explain the construction and functioning of a leadacid battery. (AU Dec 2014, June 2015, May 2016, APRIL/MAY 2023)**
5) **What is a fuel cell? Explain the working of hydrogen oxygen fuel cell? (AU Dec2014, Jan 2016, May 2016, May 2017).**
6) **Write a detailed note on breeder reactor. (AU Jan 2010, Dec 2014, May 2016)**
7) **What are the components of Ni-Cd battery? Explain its construction and advantages. (AU June 2014, May 2015, May 2017).**
8) **Write short notes on Lithium battery. (AU May 2017, APRIL/MAY 2023)**
9) **Explain the Nuclear fission and nuclear fusion reactions. (AU Jan 2016)**
10) **Explain various types of highly investigated solar cell materials?**
11) **What are electric vehicles? Explain their working principle and advantages and disadvantages?**
12) **What is microbial fuel cell? Explain its principle and working with neat diagram.**
13) Explain the working principle and applications of wind energy and geothermal energy. (APRIL/MAY 2023)