ME 2034 NUCLEAR ENGINEERING

UNIT I NUCLEAR PHYSICS

Two Mark Questions and Answers

1. **What is amu? What is its importance in nuclear physics? [Anna Univ. Nov,07]**
   The energy released by each neutron during fission process is called nuclear energy which is measured in terms of amu.
   The atomic mass unit [amu] is a unit of mass approximately equal to 1.66 x 10-24 kg. It is used to find the mass loss and nuclear binding energy of any atom.
2. **What is called plum pudding?**
   Thompson proposed a model for the atom consisting of a positive electrical field with electrons embedded into the field like plums embedded in plum pudding. It is called plum pudding model of the atom.
3. **What is nuclear binding energy/? [Anna Univ. Nov,07]**
   The energy released at the moment of combination of two nucleons to form nucleus of an atom is called "binding energy".
4. **Define mass defect. [Anna Univ. Nov,07]**
   If two or more particles interact to combine together, then the total mass of the system will decrease to be less than the sum of the masses of the individual particles. The stronger the interaction becomes, the more the mass will decrease. This decrease of the mass of the system is called mass defect.
5. **Define natural and artificial radioactivity. [Anna Univ. Nov,07]**
   Natural radioactivity is isotopes that have been here since the earth formed. Example: Uranium.

   Artificial radioactivity is produced by cosmic rays from the sun.
6. **Define Rutherford scattering.**
   The total positive charge in an atom, +Ze, concentrates on the central point of the atom, i.e. the nucleus, and the incident alpha particle is scattered with a repulsive coulomb force exerted by this nuclear point charge called Coulomb scattering or Rutherford scattering.
7. **What is atomic number and mass number?**
   The number of protons in the nuclear is called atomic number. It is denoted by 'Z'. The total number of nucleons in the nuclear is called mass number. It is denoted by the letter 'A'.
8. **List down some isotopes used in fusion reaction.**
   [i] Protium
   [ii] Deuterium
   [iii] Tritium
   [iv] Helium-3
   [v] Helium-4

9. **What is meant by elastic scattering?**
   In an elastic scattering, the reaction between a neutron and a target nucleus, there is no energy transferred into nuclear excitation. Momentum and kinetic energy of the system are conserved although there is usually some transfer of kinetic energy form the neutron to the target nucleus. The target nucleus gains the amount of kinetic energy that the neutron loses.
10. **Mention the types of cross section.**
    1. The cross section σ for a particular process which applies to a single nucleus, it is called microscopic cross section.
    2. If the cross section for the same process is considered for whole nucleus, it is called macroscopic cross section.

PART B [16 MARK QUESTIONS]

1. Discuss the advantages and disadvantages of nuclear power.
2. Discuss the elementary treatment of an atom.
3. State the law of mass energy equivalence and calculate the energy in kW likely to be produced by one gram of matter taking light velocity as 3 x 10^8 m/sec. **[Anna univ. Nov'07]**
4. Write short notes on nuclear potential.
5. Explain in nuclear binding energy? How is it measured?
6. Define 'half life', 'mean life' and 'decay constant'. **[Anna Univ. Nov'07]**
7. Explain the concept of elastic scattering and discuss how inelastic scattering differs from elastic scattering.
8. Write a brief note on 'neutron interactions' and 'cross sections'. **[Anna univ. Nov'07]**
9. Explain the various methods of determining cross section.
10. Write short notes on types of scattering cross section.

UNIT II NUCLEAR REACTIONS AND REACTION MATERIALS

Two Mark Questions and Answers

1. What are called fissile isotopes?

These fuels undergo fission process. When unstable heavy nuclear is bombarded with neutrons, it splits into two fragments of approximately equal mass. A large amount of heat is released during this fission process.

2. What are the conditions satisfied to sustain nuclear fission process?

1. The neutrons emitted in fission must have adequate energy to cause fission of another nucleus.
2. The number of neutrons produced must be able not only to sustain the fission process but also to increase the rate of fission.
3. The fission process must liberate the energy.
4. It must be possible to control the rate of energy liberation.

3. How does neutron evaporation refer?

The excited nucleus which always has an excess of neutrons relative to its fragment products, ejects or boils off a large number of neutrons in one lot and the residual nucleus breaks into two similar fragments both having nearly the same N/Z ratio called neutron evaporation.

4. Mention the types of hydrogen fusion.

[i] Magnetic confinement uses magnetic and electric field's to heat and squeeze the hydrogen plasma.

[ii] Inertial confinement uses laser beams or ion beams to squeeze and heat the hydrogen plasma.

5. Distinguish between fission and nuclear. [Anna Univ. Nov'2007]

S. No.	Nuclear fission	Nuclear fusion
1.	It is the process of breaking a heavy nucleus with some projectiles into two or more light fragments with liberation of a large amount of energy.	It is a process of fusing two light nuclei into single nucleus with the liberation of a large amount of heat.
2.	This process results in the emission of radioactive rays.	This process does not emit any kind of radioactive rays.
3.	This process takes place spontaneously at ordinary temperature.	This process takes place at very high temperature [nearly at about $> 10^5$ K].
4.	The mass number and atomic number and atomic number of the daughter elements [new elements] are considerably lower than that of the parent nucleus.	The mass number and atomic number of the product is higher than that of the starting elements.
5.	This process gives rise to chain reaction.	This process does not give rise to chain reaction.
6.	During nuclear fission, neutrons are emitted.	During nuclear fusion, protons are emitted.
7.	Nuclear fission can be performed under controlled conditions.	Nuclear fusion cannot be performed under controlled conditions.

6. List down the requirements of a moderator.

[i] It should have as low atomic mass number as possible, and

[ii] Its neutron absorbing ability should be as low as possible.

7. What is nuclear chain reaction classified?

For k =<, the operation of the reactor is said to be exactly critical which is for steady-power operation. If K<1, the reactor is sub critical and the number of neutrons is going down. On the other hand, if K<1, the system is supercritical.

8. What are the processes involved in nuclear composition of Gamma-ray Burst fireballs?

1. Neutronization in the central engine.
2. Nucleosynthesis in the fireball as it expands and cools, and
3. Spallation of nuclei in subsequent internal shocks.

9. State the role of fuel fabrication in nuclear fuel cycle.

Nuclear fuel fabrication converts the enriched UF_6 into fuel for nuclear power reactors.

10. State the benefit of reprocessing of spent nuclear fuel.

Reprocessing enables recycling of the uranium and plutonium into fresh fuel, and produces a significantly reduced amount of waste [compared with treating all used fuel as waste].

PART B [16 MARK QUESTIONS]

1. Explain the nuclear fission process with help of a neat sketch.
2. What is chain reaction? How it is maintained? What is the difference between controlled and uncontrolled chain reaction? Explain with neat sketches and with examples. **[Anna Univ. Dec'04 & Nov'07]**
3. Discuss how the nuclear chain reaction is sustained.
4. Write short notes on critical mass and nuclear composition.
5. Explain the nuclear fuel. **[Anna Univ. Apr'05]**
6. Explain the gas centrifuge method of enrichment.
7. Describe in situ leaching of uranium.
8. Write short notes on: [i] Nuclear fuel cycles and its characteristics. [ii] Uranium production and purification. **[Anna Univ. Dec'04 & Nov'07]**
9. Explain clearly [i] Nuclear fuel cycle with a neat sketch, and [ii] Spent fuel characteristics. **[Anna Univ. Dec'04 & Nov'07]**
10. Draw and explain a solvent extraction equipment. **[Anna Univ. Dec'04 & Nov'07]**

UNIT III REPROCESSING

Two Mark Questions and Answers

1. Define reprocessing as applied to nuclear fuel. [Anna Univ. Nov'2007]

Nuclear reprocessing separates any usable elements [e.g., uranium and plutonium] from fission products and other materials in used nuclear reactor fuels.

2. State the major composition of nuclear spent fuel.

95.6 % uranium [less than 1 % of which is ^{235}U]; 2.9% stable fission products and 0.9% plutonium [about two thirds fissile ^{239}Pu & ^{241}Pu].

3. Define Transmutation in nuclear reprocessing.

The process of conversion of long lived fission products to short-lived isotopes by either neutron or photon irradiation is called transmutation.

4. Define closed nuclear fuel cycle.

Reprocessing separates the uranium and plutonium from the wastes so that they can be recycled for re-use in a nuclear reactor as a mixed oxide [MOX] fuel. This is the closed fuel cycle.

5. State the stages in nuclear fuel cycle.

The nuclear fuel cycle consists of three important steps:

Steps in the front end – preparation of the fuel.

Steps in the service period – fuel is used during reactor operation.

Steps in the back end – this step is necessary to safely manage, contain, and either reprocess or dispose of spent nuclear fuel.

6. Define extraction.

Liquid-Liquid extraction is a mass transfer operation in which a liquid solution [the feed] us contacted with an immiscible or nearly immiscible liquid [solvent] that exhibits preferential affinity or selectivity towards one or more of the components in the feed.

7. Define the term selectivity in extraction.

The selectivity is expressed by the separation factor i.e. the ratio of the distribution coefficients of the desired and impurity species when equilibrium is attained between two phases.

8. Define open fuel cycle.

If spent fuel is not reprocessed, the fuel cycle is referred to as an open fuel cycle or a once-through fuel cycle.

9. Define the term distribution coefficient.

The distribution coefficient ratio D is defined as

D = Concentration of component in oranic phase / Concentration of component in aqueous phase

10. Name the common types of extractor used in nuclear industries.

[i] Mixer-Settlers

[ii] Centrifugal Devices

[iii] Column contactors [Static and agitated columns]

PART B [16 MARK QUESTIONS]

1. Explain the characteristics of spent nuclear fuel. **[Anna Univ. Nov'07]**
2. Explain the working principle with a diagram of solvent extraction equipment used in nuclear industry. **[Anna Univ. Nov'07]**
3. State the role of extraction in nuclear reprocessing.
4. Write a brief note on types of nuclear fuel cycle.
5. Explain the process of FLOUREX.
6. Write a short notes on the following processes for the extraction of fissile materials from spent nuclear fuel:

[i] UREX

[ii] TRUEX

[iii] MOX

[iv] PYRO

7. Explain the principle of extraction.
8. Explain the extraction of uranium and plutonium extraction form spent fuel using PUREX method.

UNIT IV NUCLEAR REACTORS

Two Mark Questions and Answers

1. What do you understand by moderation? [Anna Univ. Dec'04]

The process of slow down the neutrons from high velocity without capturing them is known as moderation.

2. Explain the function of the moderator. [Anna Univ. May'07]

Moderator is a material which is used to slow down the neutrons from high velocities without capturing them. The fast moving neutrons are far less effective in causing the fission and try to escape from the reactor.

3. Define the term "Breeding". [Anna Univ. Apr'05 & Nov'07]

In fast breeder reactor, the process of producing energy to self-sustain nuclear fission chain reaction without using moderator is known as breeding. Enriched Uranium [U^{235}] or Plutonium is used as fuels which are surrounded by a thick blanket of fertile Uranium [U^{238}].

4. What factors control the selection of a particular type of a reactor? [Anna Univ. Dec'04]

1. Neutrons energy
2. Type of fuel
3. Type of coolant
4. Type of moderators
5. Construction of core.

5. State the goals of generation IV.

[i] Sustainable
[ii] Economically viable
[iii] Safe and reliable
[iv] Resistant to proliferation risks and likely to be easily protected from external attack.

6. What are the different types of fast breeders? [Anna Univ. Nov'07]

[i] GFR: Gas-cooled Fast Reactor system cooled with helium
[ii] LFR: Lead Fast Reactor cooled with lead or lead-bismuth eutectic
[iii] MSR: Molten Salt Reactor fuelled with molten salts
[iv] SFR: Sodium Fast Reactor
[v] SCWR: Super-Critical Water-cooled Reactor
[vi] VHTR: Very High Temperature Reactor cooled with helium at 1000^0C at the fore outlet, for efficient production of hydrogen.

7. State the advantages of fast breeder reactors.

[i] No moderator is required [ii] High breeding is possible
[iii] It gives high power density than any other reactor.
[iv] High efficiency in the order of 40% can be obtained.
[v] Better fuel utilization. [vi] Absorption of neutrons is low.

8. What are the components of supercritical water reactor nuclear power plant? [Anna Univ. Dec'05]

1. Reactor.
2. Pressuriser
3. Heat exchanger
4. Coolant pump.

9. Write the different fuel cycle can be used in molten salt reactor.

1. Actinide burning fuel cycle.
2. Once-through fuel cycle.
3. Denatured thorium-233U breeder cycle.
4. Thorium-233U breeder cycle.

10. List down the factors not considered for heat transfer analysis.

[a] Multiphase flow
[b] Condensation with non-condensable
[c] Lower Head Cooling
[d] Fuel Debris Cool ability.

PART B [16 MARK QUESTIONS]

1. With a neat sketch explain the boiling water reactor power plant. **[Anna univ. Dec'05**]
2. Write short notes on need of nuclear energy.
3. Describe the boiling water reactor with the help of neat sketch and explain its chief characteristics. **[Anna Univ. Dec'07]**
4. Explain with a neat sketch the indirect gas cooled reactor. **[Anna Univ. Dec'05]**
5. Explain the construction and working of CANDU reactor.
6. Write short notes on the following:
   [i] Boiling water reactor
   [ii] Fast breeder reactor. **[Anna Univ. Dec'04]**
7. Explain the principle of operation of a sodium graphite reactor. **[Anna Univ. Apr'05]**
8. Explain the principle of operation of a Lead-bismuth reactor.
9. Discuss the advancement in nuclear reactors.
10. Write short notes on reactor shielding.

UNIT V SAFETY AND DISPOSAL

Two Mark Questions and Answers

1. What are the major reasons for nuclear accidents that classified under lower probability?

Cracks in coolant pipes and loss of flow are the major reasons for nuclear accidents of lower probability.

2. State the major reasons for nuclear accidents that classified under moderate frequency.

The major reasons for nuclear accidents of moderate frequency are imbalance in heat rates. Increase in thermal power and decrease in cooling effectiveness.

3. State the major reasons for nuclear accidents that classified under severe accidents.

The major reasons for nuclear accidents of severe category are large break of loss coolant, loss of power in reactor station and failure of reactor protection system.

4. State the engineered nuclear plant safety measures adopted.

The major engineered safety features are

[i] Emergency cooling system to supply water to the reactor core in the event of a loss of coolant accident.

[ii] The containment vessel to provide a barrier to the escape to the environment of radioactivity.

[iii] Clean up system for removing part of the radioactivity and heat that may be present in the contamination atmosphere.

[iv] Hydrogen control to prevent formation of explosive hydrogen – oxygen mixture in the containment.

5. What are the criteria used for evaluation of nuclear plant safety? [Anna Univ. Nov'07]

The criteria used for the evaluation of nuclear plant safety are

[i] No unreasonable risk
[ii] Adequate protection of public health and safety
[iii] Risk as low as reasonably practicable
[iv] Safety as high as reasonably achievable
[v] Limit risk by use of best technologies at acceptable economic costs.

6. State the major problem encountered in nuclear power generation.

The nuclear power generation poses mainly two problems such as

[i] The management of radioactive waste, and
[ii] The danger passed in case of accident is very high and long standing.

7. How nuclear wastes are classified? [Anna univ. Nov'07]

The nuclear wastes are classified as:

[i] On the basis of half life time
  [a] Fission products
  [b] Actinides
  [c] The neutron activation products.

[ii] On the basis of the intensity of radiation
  [a] Low level waste
  [b] Medium level waste
  [c] High level waste.

8. What are the types of radiation which has the ability to penetrate objects or bodies?

Alpha, Beta, and gamma radiation.

9. State the common units of radiation.

Roentgen: This is defined as the quantity of radiations that will produce as result of ionization, electrons carrying a total charge of 2.58×10^{-4} coulomb in 1 kg of dry air.

Rad: The absorbed dose unit is called as rad which is defined as the amount of radiation that leads to deposition of 10-2J of energy per kg of the absorbing material.

Rem: The effect of a given adsorbed dose of radiation is expressed in terms of the dose equivalent for which the unit is rem.

10. State the beneficial uses of nuclear radiation.

[i] Nuclear radiation has a number of beneficial uses, including.
[ii] Medicinal, such as radio therapy for cancers and X-rays.
[iii] Dating purposes [no, this not where you nuke a 'toxic' date]
[iv] Level indicators and thickness gauges.
[v] In smoke detectors and
[vi] In tracing locations of gas or liquid leaks or
[vii] Tracing locations of malfunctioning in the body such as a blocked kidney.
[viii] Sterilization of medical instruments or bacteria or moulds in foods.

PART B [16 MARK QUESTIONS]

1. Explain the criteria for nuclear safety system. **[Anna Univ. Nov'07]**
2. Discuss about the safety measures adopted in modern nuclear plants. **[Anna Univ. Nov'07]**
3. Explain with a neat diagram the disposal of low level solid nuclear wastes. [**Anna Univ. Nov'07]**
4. Explain about the effects of nuclear radiation on parts of human beings. **[Anna Univ.'07]**
5. Discuss about the reasons for nuclear accidents classified based on the source.
6. Explain about the nuclear safety inspections.
7. Explain about the nature of wastes generated from each stage of nuclear fuel cycle.
8. Explain with a neat diagram the disposal of high level solid nuclear wastes.
9. Explain about the disposal of gaseous nuclear wastes with a diagram.
10. Write a short note on plutonium bomb.