ANNUAL UPDATE ON ALL THINGS NUCLEAR POWER

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BIO

- Andrew Ohrablo
  - Bachelor of Science Nuclear Engineering – University of Wisconsin at Madison
    - Senior Thesis – Design of Liquid Metal Fast Breeder Reactor
  - Perry Nuclear Power Plant, Perry, OH 2014-Present
    - Maintenance Engineering Supervisor – Current Position
    - Maintenance Electrical Engineer
    - Work Week Manager
  - Cooper Nuclear Station, Brownville, NE 1999-2014
    - Shift Technical Engineer
    - Senior Reactor Operator NRC License Number 44337
  - United States Navy Nuclear Electrician – USS Enterprise 1987-1993

CALIFORNIA ELECTRIC MARKET

- Diablo Canyon only remaining nuclear power plant in California
  - Designated to close unit 1 in 2024 and unit 2 in 2025
- August of 2022, California bans sale of gas powered automobiles by 2035
- September of 2022, California request drivers of electric vehicles to not charge their cars during peak hours to help prevent rolling blackouts from heat wave
- DOE funding available for struggling reactors
- California makes decision to change state law to allow five additional years of operation for Diablo Canyon
- November 1, 2022, PG&E request NRC to resume relicense activities.

INTERNATIONAL AFFAIRS

- Zaporizhzhia Situation
  - Largest nuclear facility in Europe with 6 VVER-1000 pressurized water nuclear reactors
  - In disputed territory of Ukraine
  - All but one reactor shutdown due to the conflict
  - IAEA Inspectors on site
- Chernobyl
  - Russian RBMK design with four reactors of 1000MW each
  - Hydrogen explosion in unit 4 April 26, 1986 during a shutdown safety test resulting in 57 attributed deaths and release of significant radioactive contamination
  - All reactors are currently shutdown and in decommissioning.
  - Captured by Russians but returned to Ukraine when numerous soldiers fell ill in the area.
- Germany
  - Required that their three remaining nuclear power plants be shut down by end of year
  - Extended the shutdown dates to end of April 2023 based on the Ukraine-Russian war.

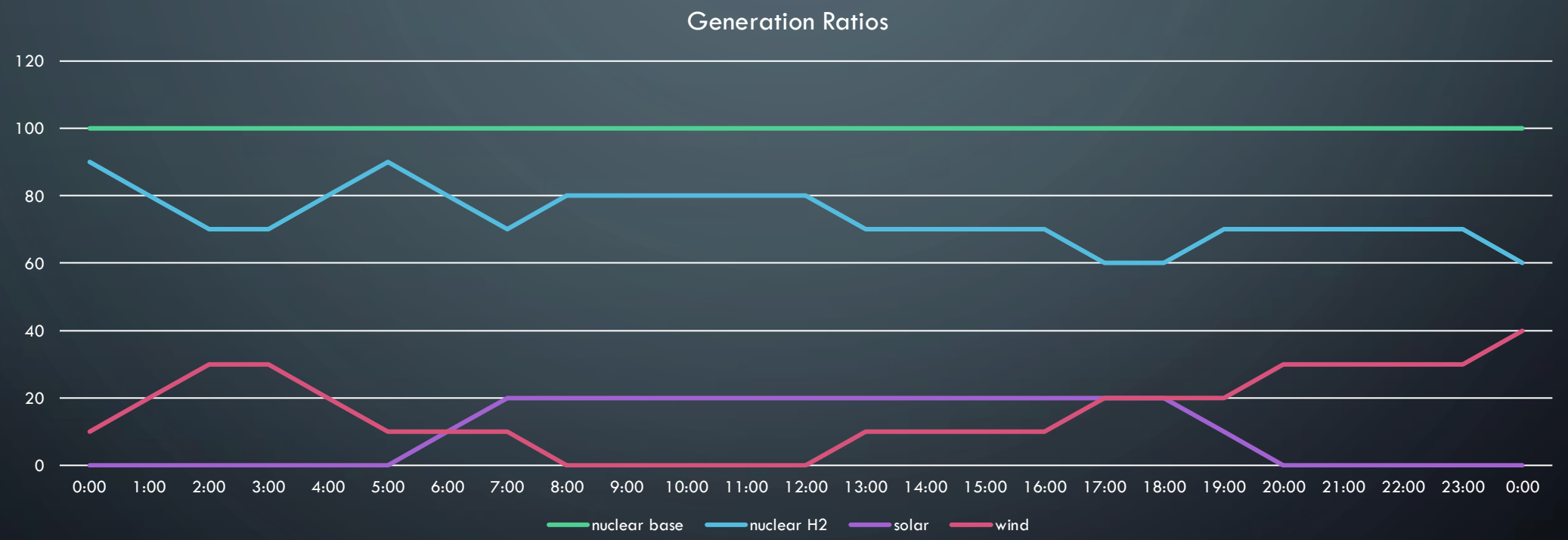
GREEN ACTIVITIES FOR NUCLEAR POWER

- Hydrogen Production
  - Davis Besse pilot plant for hydrogen generation
- Why it matters?
  - Allows large scale nuclear power plants to integrate with intermittent renewable sources.
  - Product allows for Carbon free combustion engines.
- How it works?
  - Nuclear plants are designed to run at 100%.
  - Previously, if wind or solar were cheaper they are required to be allowed on the market. This resulted in nuclear plants backing power down or selling at negative cost.
  - With Hydrogen production, can divert excess electrical generation to produce Hydrogen alleviating the need to lower power.
  - Byproduct of excess generation is now a commodity.

HYDROGEN PRODUCTION

- Electrolytic decomposition of water
- Uses Direct Current Electricity to break apart the molecular bonds of water to release the Oxygen and the Hydrogen
- Requires large amounts of electricity
- Oxygen and Hydrogen separated and either or both can be stored for future use
- Normal process for Hydrogen production utilizes natural gas that emits Carbon DiOxide

WHY IT MATTERS?



COUNTRIES WITH NUCLEAR POWER PLANTS

- United States
- Canada
- France
- Germany
- India
- Brazil
- Argentina
- Sweden
- Finland
- England
- Norway
- China
- Russia
- South Africa
- Czech Republic
- United Arab Emirates
- Egypt
- Slovakia
- Bulgaria
- Iran

COUNTRIES WITH NUCLEAR BUILDS OR PLANS

- United States
- Canada
- France
- Poland
- India
- Brazil
- Argentina
- Iran
- Finland
- England
- Philippines
- Estonia
- China
- Russia
- Latvia
- Czech Republic
- United Arab Emirates
- Egypt
- Slovakia
- Bulgaria
- Iran
- Thailand

COAL TO NUCLEAR

- Utilize the current infrastructure to transfer coal burning power plants to nuclear fueled power plants
- Terra Power plant – owned by Bill Gates
- Kemmerer Wyoming selected for first plant – goal 2028
- Goal to build at four additional sites

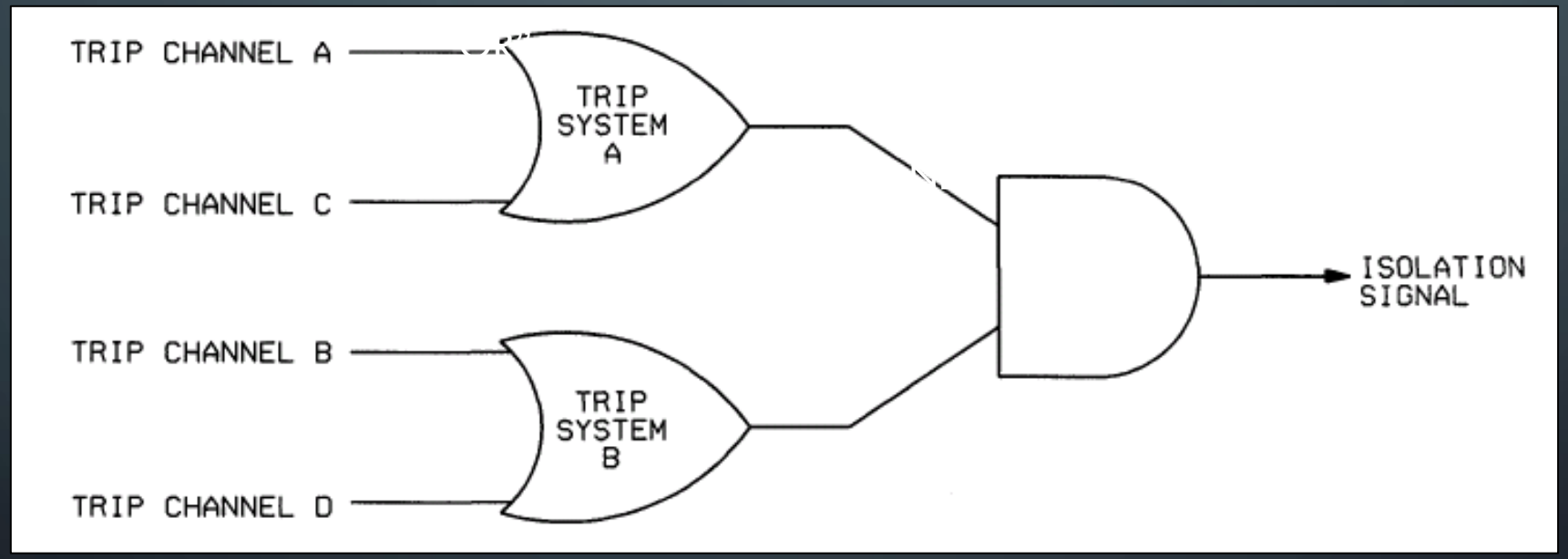
HOW ARE REACTORS PROTECTED

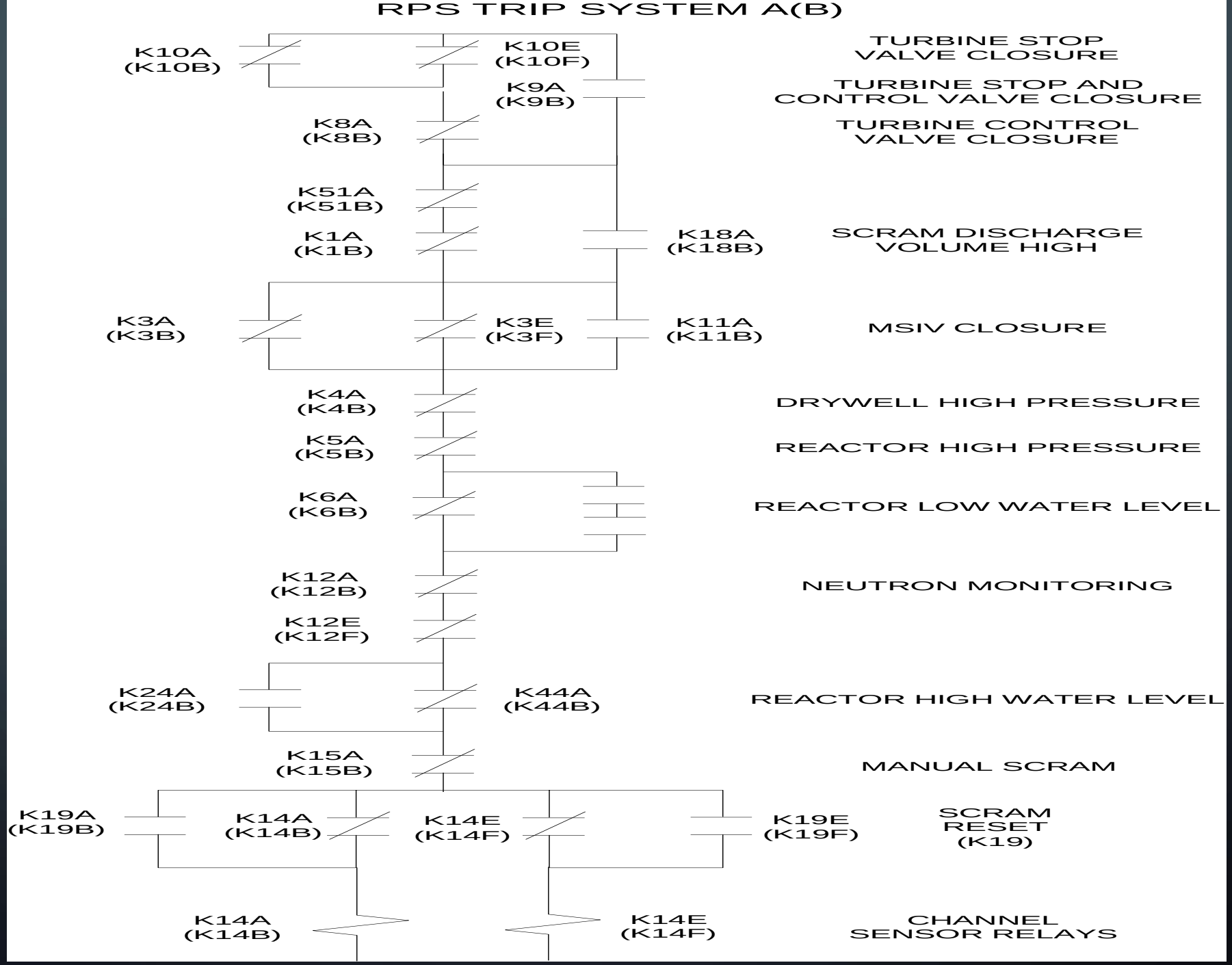
- De-energized to actuate logic in a one out of two taken twice configuration.
- Parameters monitored
  - Reactor Power
  - Reactor Level
  - Turbine Trip/Governor Valve Position/Trip Header Pressure
  - Reactor Pressure
  - Scram Discharge level
  - Main Steam Isolation Valve Position
  - Mode Switch
  - Manual

HOW ARE REACTORS PROTECTED

- Protection Scheme
  - Normally one out of two taken twice
  - Each parameter has minimum of four protection channels
  - These feed into two logic channels
  - If a parameter reaches its limit it drops out the relevant relay and de-energizes the RPS relay resulting in a half scram
  - If both logic channels see the same event prior to reset, then both RPS relays de-energize and the control rods are inserted into the core

1 OUTTA 2 TWICE




RPS TRIP SYSTEM A(B)
K10A
(K10B)
K10E
(K10F)
TURBINE STOP
VALVE CLOSURE
K9A
(K9B)
TURBINE STOP AND
CONTROL VALVE CLOSURE
K8A
(K8B)
TURBINE CONTROL
VALVE CLOSURE
K51A
(K51B)
K1A
(K1B)
K18A
(K18B)
SCRAM DISCHARGE
VOLUME HIGH
K3A
(K3B)
K3E
(K3F)
K11A
(K11B)
MSIV CLOSURE
K4A
(K4B)
DRYWELL HIGH PRESSURE
K5A
(K5B)
REACTOR HIGH PRESSURE
K6A
(K6B)
REACTOR LOW WATER LEVEL
K12A
(K12B)
NEUTRON MONITORING
K12E
(K12F)
K24A
(K24B)
K44A
(K44B)
REACTOR HIGH WATER LEVEL
K15A
(K15B)
MANUAL SCRAM
K19A
(K19B)
K14A
(K14B)
K14E
(K14F)
K19E
(K19F)
SCRAM
RESET
(K19)
K14A
(K14B)
K14E
(K14F)
CHANNEL
SENSOR RELAYS

ANALYZED TRANSIENTS AND PROTECTION METHOD

- Abnormal Operating Transient (AOT)
  - Expected to occur at least once in forty years of license
- Incidents of moderate occurrences
  - Not expected to occur within forty years of license (analyzed as AOT)
- Special Events
- Design Basis Accidents
  - Never expected to occur

ANALYZED TRANSIENTS AND PROTECTION METHOD

- Pressure Increase –collapses voids and raises power – protected by APRM upscale trip, MSIV Position
- Temperature decrease of feedwater – adds positive reactivity and power rise – protected by APRM upscale trips
- Loss of inventory (leak) – less cooling water – low level reactor scram
- Increase in reactivity – Rod drop out – APRM upscale trip
- Decrease in reactivity – Rod drop in – Manual Scram
- Increase in inventory – Carry over of water to turbine causing damage - Turbine Trip

SPECIAL EVENTS

- Events that were not originally credible but occurred
  - Anticipated Transient without scram – Alternate shutdown room and Scram DischargeVolume level high scram
  - Station Blackout – Loss of offsite power and backup diesel generators - Steam driven turbines and Flex equipment utilized to maintain the core covered
  - Fire in control cables, loss of control from control room – alternate shutdown room – manual scram
  - Shutdown without control rods – Standby Liquid Control System, Scram Discharge Volume high level scram

DESIGN BASIS ACCIDENTS

- Worst Case Scenarios that are limiting in all cases
- Not postulated to occur
  - Loss of Coolant Accident
  - Loss of Coolant Accident concurrent with Loss of Off-site power
  - Refueling fuel handling accident

QUESTIONS?

CITATIONS

- * NRC regulations 10CFR20 & https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html
- **BC Campus, College Physics Biological effects of Ionizing Radiation https://opentextbc.ca/physicstestbook2/chapter/biological-effects-of-ionizing-radiation/

TERMS

- Critical – status of nuclear reactor where the number of neutrons in one generation is equal to the number of neutrons in the previous generation – power is remaining constant
- Reactivity – Relative departure from critical for a nuclear reactor
- Sub-Critical – status of nuclear rector where the number of neutrons in one generation is less then the number of neutrons in the previous generation – power is going down
- Super-Critical – status of nuclear rector where the number of neutrons in one generation is more then the number of neutrons in the previous generation – power is going up

TERMS (CONTINUED)

- Barns – measure of cross section of a nucleus for a specific reaction – higher barns means a nucleus is more likely to react
- Absorption – nuclear reaction where an incident particle is absorbed into the nucleus
- Capture – Nuclear reaction where an incident particle remains in the nucleus following absorption
- Fission – nuclear reaction where an incident particle results in the mother nuclear splitting into two or more nuclei
- Beta Decay – where an excited nucleus releases energy in the form of a positron or electron and a nucleon is changed from a proton or neutron to bring the nucleus to a lower energy state
- Alpha decay – where an excited nucleus releases an alpha particle to bring the nucleus to a lower energy state
- Alpha Particle – Essentially a helium atom without the electrons. Two protons and two Neutrons