Saigon International College

SCIENCE DEPARTMENT
Physics ATAR YEAR 11
Semester 1

Task 4: Investigation

Nuclear Power Plant Design and Function

Task Weighting: 6% of the school mark for this pair of units

Time: 60 minutes

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Score: 43/50 Excellent

Scanned with CamScanner

Nuclear Power Plants

This is a diagram of a pressurized water reactor. This is the most common type of nuclear reactor found in the United States and throughout Western Europe. Identify and label each of the major parts of the power plant. [15]

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Word bank: ① control rods ② fuel rods ③ reactor ④ primary loop ⑤ secondary loop ⑥ feedwater loop ⑦ water pump (x2) ⑧ condenser (x2) ⑨ turbine ⑩ generator ⑪ transmission lines ⑫ cooling tower ⑬ containment building

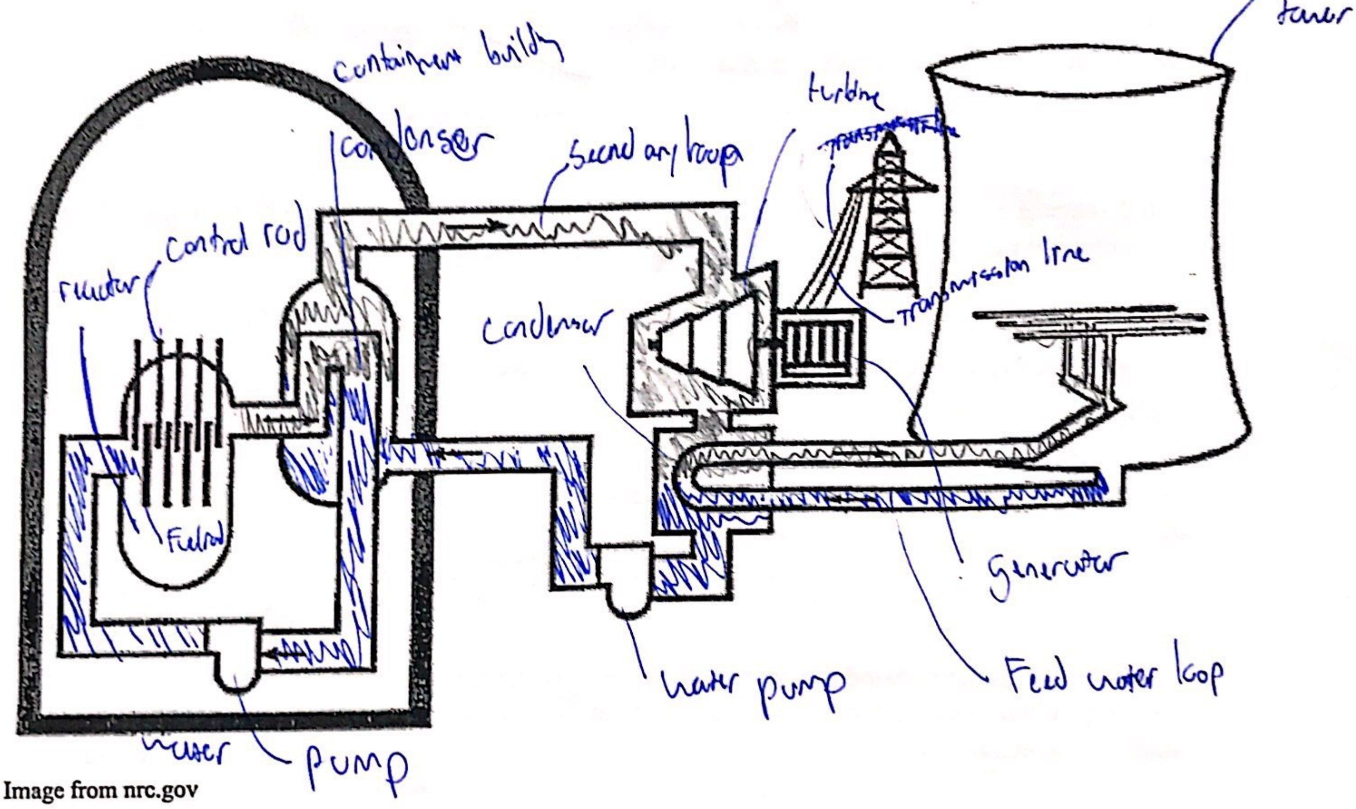


Image from nrc.gov

1. In the **primary loop,** water passes through the pump and enters the reactor. Color the areas of liquid water blue. In the **reactor,** the water boils and turns to steam. It remains as steam until it passes by the secondary loop **condenser**. Color the areas of steam red. [2]

2. Color-code the water and steam in the **secondary loop.** Steam should be exiting the condenser. It becomes liquid water again below the turbine as it passes by the feedwater loop condenser. [2]

3. Color-code the water in the **feedwater loop.** It is liquid water until it passes through the condenser below the turbine, then steam until it enters the cooling tower. [2]

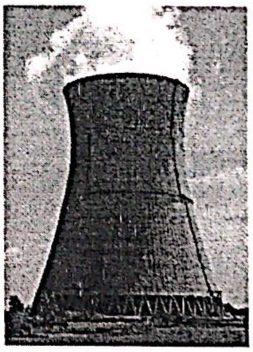
absorb excess spare

Review Questions

4. Why is the reactor coolant water kept contained within the primary loop instead of allowing it to mix with the feedwater and leave through the cooling tower? [3]

This is because inside the reactor coolant water there are neutrons and radio active material. so If this water is allowed to leave through the cooling tower it will give off radio active material out into the atmosphere

5. You drive past a nuclear power plant cooling tower that looks like the image to the right. What is coming out of the tower and entering the air? Is it radioactive? [3] 2



Steam is coming out of the cooling tower, this steam is not radio active. This steam is normal water and is not radio active

how do you know?

6. Control rods can be inserted or removed from the core depending on the amount of electricity demand. What position does the diagram show the control rods in? Does this mean there is a high or low electricity demand? [3]

The control rod is in a high position, there is a high electricity demand. The control rod in this situation allow more of the fuel rod to react with neutrons, therefore producing more energy

7. What are the outer walls of the containment building made of? Why is this important? [3]

It is made of thick concrete. This is important to contain radiation in case there is a nuclear melt down. Thick concrete can stop gamma radiation from escaping the facility. Containment

8. All nuclear power plants have backup generators in case the plant stops producing electricity. Why is this necessary? What exactly are the generators providing power for? What might happen if these backup generators fail? [5]

Nuclear power plants needs back up generator because their mechanisms ~~on~~ constantly need electricity. they ~~are~~ providing power for the water pumps. If there is no power, the water pumps cannot work ~~and~~ In a nuclear power plant, water must be constantly pumped in and out of the 3 loops to cool the power plant. The power plant will overheat because of a melt down if these water pumps do not have power to pump. In the Reactor, water is constantly being pumped back into the reactor as steam ~~takes~~ evaporate away from the heat generated. If the pump stops and the ~~evapora~~ ~~steam~~ heat is constantly being produced causing ~~an~~ steam to evaporate, there will no longer be enough water to cool the reactor

9. In a fast breeder reactor, a neutron, mass 1.00867 u, causes fission of Pu-239 (239.05216 u). One of the two fission fragments is Tc-104 (103.91145 u) and three neutrons are released. The atomic mass of the other fragment is 132.91525 u.

a) State what it is meant by a fast breeder reactor. [1]

A fast breeder reactor does not need to slow down the ~~the~~ neutrons to ~~generate power~~ continue the chain reaction.

b) Construct the decay equation as outlined in the text. [2]

$^{239}_{94}Pu + ^{1}_{0}n \rightarrow ^{103}_{43}Tc + ^{132}_{43}Tc + 3\,^{1}_{0}n$

c) Calculate how much energy, in MeV, is produced by this nuclear reaction. Show all working clearly. [5]

~~103.91145 + 239.05216 = 342~~

103.91145 + 132.91525 = 236.8267

+ 3(1.00867) = 239.85271

− 239.05216 = 0.80055 u

0.80055 × 931.5 = 745.712

746 MeV

d) If the average power consumption for Perth city is 600 MW daily, calculate the mass of Pu-239 (in kg) required to provide Perth city with enough energy for 30 days. [4]

3

600 MW daily = 600 000 000 W daily

19
− 6
13

1 MeV = 1.6×10^{-13} J

~~= 3.75×10^{21}~~

$^{239}_{94}Pu$ = 746 MeV = $(1.6 \times 10^{-13}) \times 746$ = 1.1936×10^{-10} J

(−1).

600 000 000 ÷ 1.1936×10^{-10} = ~~5.0268097×10^{18}~~

~~0.050~~

5.0268095×10^{18} Units? Pu atoms

weight of 1 Pu:

~~239 Pu~~ 239.05216 u

1 u = 1.66×10^{-27} kg

~~=> we need~~

=> we need this much Pu atoms at 239.05216 u per atom

$5.0268097 \times 10^{18} \times 239.05216$

total mass = ~~1.0~~ $1.201669705 \times 10^{21}$ u

$\times\ 1.66 \times 10^{-27}$

~~1.994771×10^{48} kg~~

1.994771×10^{-6} kg

too small,

please be right :(