

**Physics 2204**  
**Unit 3: Work, Power and Energy**  
**Worksheet 15: Nuclear Energy**

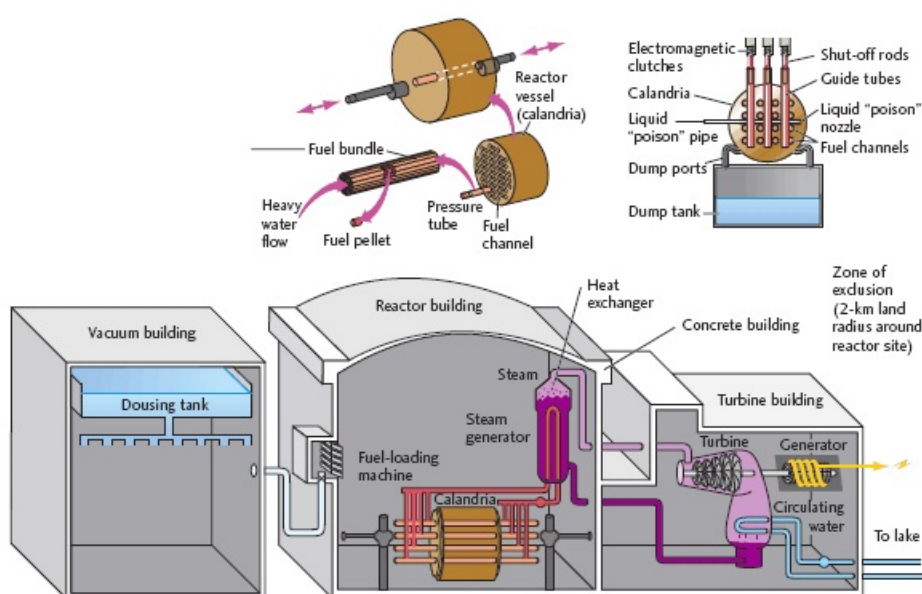


Student Name: \_\_\_\_\_

### Nuclear Energy and Reactors

We have all heard of the enormous energy released from a nuclear fission bomb (A-bomb) or the even more destructive nuclear fusion bomb (H-bomb). However, through controlled reaction rates this energy can be harnessed in nuclear power reactors. Canada has built a world renowned reactor known as a CANDU reactor, **CAN**adian **D**euterium **U**ranium.

**The CANDU reactor** gets energy from the fission of Uranium which occurs in its many fuel bundles.



**Calandria** is the reactor core that contains a moderator, and the nuclear fuel to achieve nuclear fission.

**Nuclear fuel** ( natural uranium 235) is a material that can be consumed to derive nuclear energy

**Moderator** is a medium which reduces the velocity of fast neutrons,

**Deuterium** (Heavy water) is used as a modulator. Heavy water is chemically and physically identical to regular water, with the exception that the extra neutron in each atom of hydrogen makes it more dense.

**Control Rods** (shut off Rods) control the distribution of power in the reactor and can be used to shutdown the reactor.

Heavy water, containing Deuterium instead of normal hydrogen, is pumped through the core, or calandria, to act as a moderator and slow down the emitted neutrons so as to sustain the reactions.

The heavy water,  $D_2O$ , (at high pressure so as to not boil) also absorbs heat from the reaction and passes this heat onto ordinary water in a heat exchanger. The ordinary water becomes steam and is used to turn a turbine which is connected to an electromagnetic generator to produce electrical energy.

The fission reaction occurs in the fuel bundle. Heavy water, or deuterium oxide, is used to moderate the fast neutrons in the reactor. This water especially good at slowing down fast neutrons while being able to absorb the heat produced during the reaction. The heat is carried out

of the reactor by water pumps to a heat exchanger, where it is passed on to an ordinary water supply loop to avoid the possibility of radioactive products leaving the reactor area. The hot ordinary water produces steam, which turns the steam turbine and the electromagnetic generator connected to it. The steam emerging from the turbine is cooled and condensed back to water by cooling water, usually supplied from a nearby body of water, such as a lake.

### CANDU Safety Systems

- 1) Moderator Dump - The heavy water moderator passes through the calandria by gravity. If no more heavy water is ‘poured’, the reactions stop because there is no moderator slowing down neutrons.
- 2) Cadmium Control Rods - Cadmium rods, which absorb neutrons, can be lowered into the core remotely to control the reactions. These rods are dropped from electromagnetic clutches and stop the reactions, if there is a power outage.
- 3) Moderator “Poison” - A neutron-absorbing solution can be injected into the moderator. This stops the chain reactions, while also cooling the core.

Known the pros and cons of nuclear power:

Issue	For Nuclear Energy	Against Nuclear Energy
Demand for Electricity	The demand for electricity will keep increasing, so the way in which we generate electricity must be able to keep up	Energy conservation and efficiency improvements could reduce the growth rate for electricity demand while at the same creating jobs
Fuel Availability	Uranium, the fuel for nuclear fission, is indigenous to which frees us from depending on expensive importing of oil and natural gas.	Uranium mining in Canada disturbs buried radioactive material. Exposed radioactive material is called <b>radioactive tailings</b> . It leaches into the soil and groundwater, causing radioactive contamination of sensitive ecosystems
Safety	Everything we do involves risk , and there is certainly no way to generate the power that we need risk free. The safety of CANDU reactors has been proven and is a technology that is available now	Any safety record has been based on limited operational experience. Any health and environmental effects may take years to manifest themselves, when they do, the result is long term and catastrophic
The Environment	Compared to burning coal, CANDU reactors are much more environmentally friendly. The highly radioactive waste that is produced does not take up much volume	The nature of the effects of exposure to radioactive isotopes means that any negative health and environmental effects will not be realized for years. No permanent and safe methods for the disposal of long-lived high-level radioactive have been employed as of yet
Cost	High capital costs at the outset will be more than offset by a plenitude of safe and inexpensive power for years to come.	Nuclear power is very centralized and capital cost intensive. Quite often, the costs may be hidden due to various government subsidies

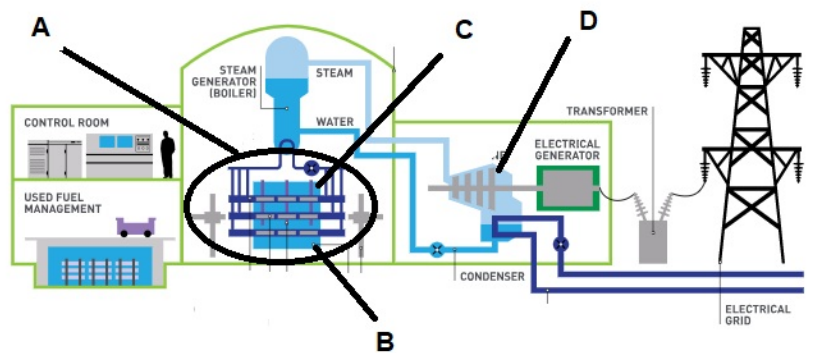
## PART A: MULTIPLE CHOICE

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided

1. What is nuclear energy?
  - (A) Energy that is created by the sun
  - (B) Energy released by a nuclear reaction, especially by fission
  - (C) Energy created by hydroelectricity
  - (D) Renewable energy made by wind and solar power
  
2. How is nuclear energy produced?
  - (A) A chemical reaction
  - (B) Fission
  - (C) Fusion
  - (D) Radon gas
  
3. What does critical mass mean in nuclear energy production?
  - (A) Chain reaction that causes automatic splitting of the fuel nuclei has been established
  - (B) It is capable of generating much more than rated capacity
  - (C) It is generating power to rated capacity
  - (D) There is danger of nuclear spread
  
4. Which of the following is important in a nuclear chain reaction?
  - (A) Electron
  - (B) Gamma Ray
  - (C) Neutron
  - (D) Proton
  
5. What element is used in nuclear power plants as fuel?
  - (A) Carbon
  - (B) Nitrogen
  - (C) Oxygen
  - (D) Uranium
  
6. What is the function of the moderator in nuclear plants?
  - (A) Cause collision with the fast moving neutrons to reduce their speed
  - (B) Control the reaction
  - (C) Extract heat from nuclear reaction
  - (D) Reduce temperature
  
7. What is the function of the control rods in a fission reactor?
  - (A) Absorbs slow neutrons
  - (B) Increases the speed of neutrons
  - (C) Prevents heat loss from the core
  - (D) Transmits gamma rays
  
8. What is the purpose of the moderator surrounding the fuel in a nuclear reactor?
  - (A) Absorb neutrons
  - (B) Decrease speed of neutrons
  - (C) Increase speed of neutrons
  - (D) Release neutrons

9. Which of the following refers to a neutron-absorbing solution that stops the chain reactions, while also cooling the core?
- (A) Cadmium Control Rods  
 (B) Calandria  
 (C) Moderator Dump  
 (D) Moderator "Poison"
10. Which of the following is an advantage of nuclear energy?
- (A) Nuclear waste is not radioactive  
 (B) Nuclear power plants are low in cost  
 (C) Nuclear energy does not produce air pollution  
 (D) Waste can be stored anywhere
11. Which of the following is a disadvantage of nuclear energy?
- (A) Nuclear energy produces less energy than other forms  
 (B) Nuclear energy is not reliable  
 (C) Nuclear waste must be safely stored  
 (D) The fuel sources are limited
12. What dangerous byproduct is produced by nuclear power plants?
- (A) Carbon dioxide  
 (B) Methane  
 (C) Smoke  
 (D) Radioactive waste

Use the picture below to answer questions 13 to



13. What does letter A represent?
- (A) Cadmium Control Rods  
 (B) Calandria  
 (C) Moderator  
 (D) Steam turbine
14. What does letter B represent?
- (A) Cadmium Control Rods  
 (B) Calandria  
 (C) Moderator  
 (D) Steam turbine
15. What does letter C represent?
- (A) Cadmium Control Rods  
 (B) Calandria  
 (C) Moderator  
 (D) Steam turbine
16. What does letter D represent?
- (A) Cadmium Control Rods  
 (B) Calandria  
 (C) Moderator  
 (D) Steam turbine



