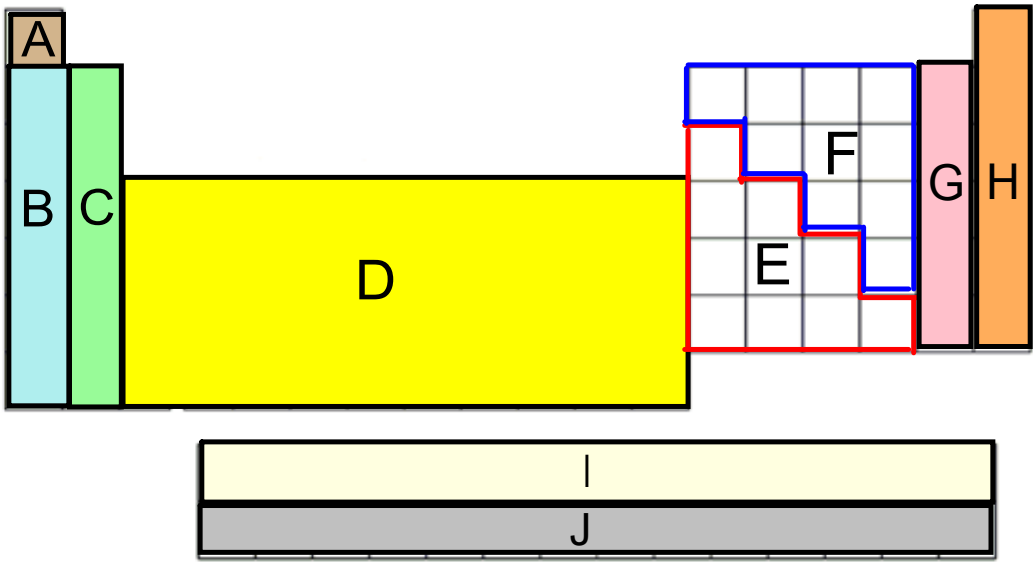
Pretest: Nuclear Technology (PSC - 4010)

1.




In which section(s) would you find:

a) the metals? B, C, D, E, I, J

b) the nonmetals? A, F, G, H

c) the halogens? G

d) the actinides? J

e) the alkaline earth metals? C

f) the alkali metals? B

g) the noble gases? H

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2. For each of the following statements, indicate the atomic model theory (i.e. Ancient Greeks, Dalton, Thomson, Rutherford, Bohr, or current simplified atomic model) to which it refers.

a) At the time of the Industrial Revolution, this man conducted experiments and made observations that allowed him to build on Democritus' atomic theory.

Ans: Dalton

b) The existence of electrons was confirmed through observations that cathode rays were deflected in magnetic fields.

Ans: Thomson

c) All of matter is made of four basic elements: earth, air, water, and fire.

Ans: Ancient Greeks

d) It concluded that the movement and distribution of electrons in atoms will affect how atoms react.

Ans: Bohr (2,8,8...

e) Much thought was given in attempts to answer the question: "What is the nature of matter?"

Ans: Ancient Greeks

f) Gold foil was bombarded with helium nuclei, and this led to the conclusion that nuclei contain positively charged protons.

Ans: Rutherford

3. Refer to the period table, and fill in the following chart:

**Information on Bromine**

Symbol: Br

Atomic number: 35

Atomic mass: 79.90 u

Number of protons: 35

Number of electrons: 35

Number of neutrons: 45 (80 − 35)

Group number: 7

Period number: 4

Number of energy levels: 4

Number of electrons in the outermost energy levels: 7

mass − atomic #

4. In a sample of pure neon gas:

- the mass number of 90.48% of the atoms is 20

- the mass number of 0.27% of the atoms is 21

- the mass number of 9.25% of the atoms is 22

Using the above information, calculate the average atomic mass of magnesium.

Show all steps in the solution.

$\frac{90.48}{100}(20) = 18.096$

$\frac{0.27}{100}(21) = 0.0567$

$\frac{9.25}{100}(22) = 2.035$

$20.1877\ u$

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5. For many years a variety of scientists made contributions towards developing our understanding of what an atom looks like.

a) What was Chadwick's contribution? That is, what did he add to Bohr's model in order that we would be left with the current simplified atomic model?

neutrons in the nucleus (1) (1)

b) Identify three features of Bohr's model that remain in the simplified atomic model.

- electrons travel in orbits
- nucleus is very small
- nucleus is very dense
- most of atom is spaced

c) List two similarities between Thomson's model and Rutherford's model.

plum pudding

- there are positive and negative particles present
- atom is neutral (or, # + chgs = # - chgs) (1)

d) List three differences between Thomson's model and Rutherford's model.

In Rutherford:

(1) protons are concentrated in nucleus
(2) most of atom is empty space
(3) nucleus is very dense

6. Consider the following fictitious elements. They have been assigned the symbol "E" and identified using atomic notation.

$^{62}_{31}E$ $^{64}_{32}E$ $^{62}_{30}E$ $^{61}_{29}E$ $^{65}_{30}E$

#n = 62 − 30 * Same atomic # #n = 65 − 30

a) Which are isotopes of the same element?

$^{62}_{30}E$ and $^{65}_{30}E$

b) How many protons do these isotopes have?

30

c) How many neutrons do these isotopes have?

32 and 35

7. Several different units are used to measure the intensity of radiation.

In the following table, match each definition with the corresponding unit of measurement.

**Write the appropriate number in the parentheses after each definition.**

| Definition | Unit of Measurement |
|---|---|
| a) Smallest unit used to measure the number of disintegrations per second. ( 1 ) | 1. The becquerel |
| b) Largest unit used to measure the quantity of energy absorbed per kilogram of living tissue. ( 6 ) | 2. The sievert |
| c) Smallest unit used to measure the radiation dose resulting in biological damage when absorbed by the human body. ( 4 ) | 3. The curie |
| d) Largest unit used to measure the number of disintegrations per second ( 3 ) | 4. The rem |
| e) Smallest unit used to measure the quantity of energy absorbed per kilogram of living tissue. ( 5 ) | 5. The rad |
| f) Largest unit used to measure the radiation dose resulting in biological damage when absorbed by the human body. ( 2 ) | 6. The gray |

8. Complete the following sentences by choosing the correct missing word:

a) The greater the mass defect the ___more___ (more or less) energy released during nucleus formation.

b) The less nucleons in the nucleus the more ___stable___ (stable or unstable) the nucleus.

c) The more stable the nucleus the ___smaller___ (smaller or greater) the number of nucleons in the nucleus.

d) The ___smalley___ (smaller or greater) the mass defect the more unstable the resulting atom.

↑m.d ↑ stable

9. Place a (P) for physical change, a (C) for chemical change, or an (N) for nuclear change in each of the spaces below.

C ___ When propane or any other gas is burned it is converted to steam and carbon dioxide ($CO_2$).

P ___ In a conventional thermal power plant, water in the boiler unit is converted into steam.

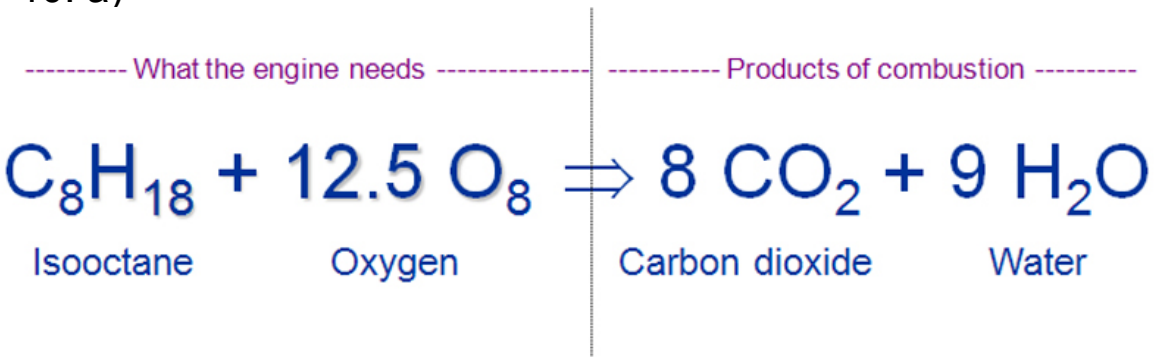
N ___ Since polonium is unstable it decays to lead.

C OR N ___ When food is exposed to Co-60 its decay process is slowed.

C ___ Silver will turn greyish-black when it is placed in a bag with cooked egg white.

P ___ If iron filings are placed in a magnetic field, the iron filings themselves will turn into little magnets.

10. a)




The above equation shows what happens in a car engine. Explain why is this considered a chemical reaction.

New molecules are produced.

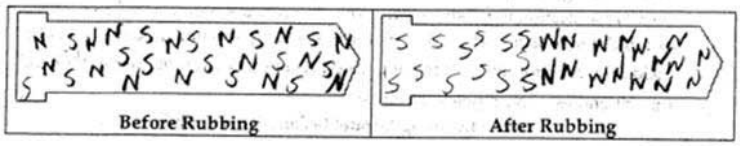
b) $^{210}_{84}Po \longrightarrow {}^{206}_{82}Pb$

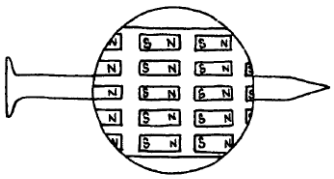
How do you know that the equation to the left represents a nuclear reaction?

Answer: A new element is produced.

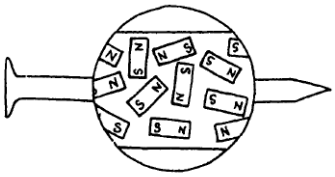
10. c) When regular iron nails are exposed to a magnetic field (e.g. rubbed with a magnet):

... The nails themselves become temporary magnets! :



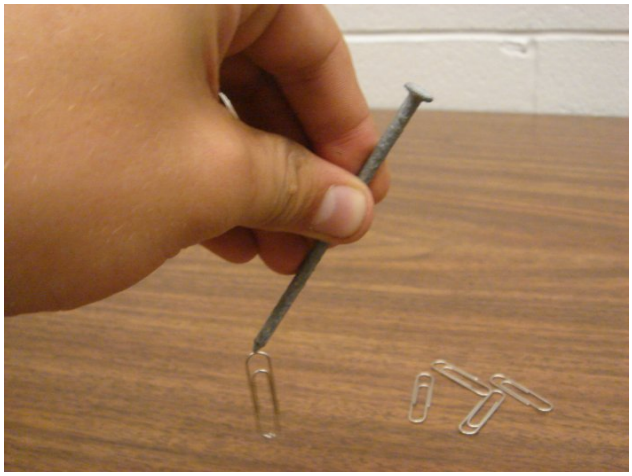



MAGNETIZED



DEMAGNETIZED

... and then the nail can be used as a magnet to pick up substances which are made of magnetic metals (like iron, cobalt, and nickel)! :



Explain the reason that this would be considered a physical change.

It's still the same substance!

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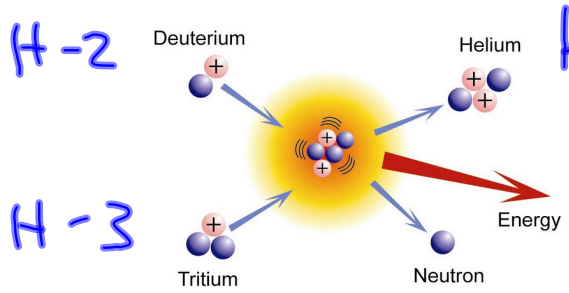
11. Indicate whether each of the following statements is true (T) or false (F):

a) Natural radioactivity is not emitted spontaneously. F

b) The following represents a nuclear fusion reaction:




T

c) The fusion of a given quantity of matter produces more energy than the fission of the same quantity of matter. T

d) The decay rate of a radioactive isotope will increase if the pressure is increased. F

e) Radioactivity produced by artificial radioactive elements is not emitted spontaneously. T

f) In a nuclear fusion reaction the total mass of the resulting atoms is slightly less than the total mass of the initial atoms. T

g) If the uranium is heated, then it will fission more quickly in a nuclear reactor. F

12. A 10-kilogram sample of radioactive waste from a nuclear power plant contains 30 milligrams of radium-226. How much radium-226 will be left in this sample after 11 200 years? The half-life of radium-226 is 1600 years.

| time (y) | mass (mg) |
|---|---|
| 0 | 30 |
| +1600 → 1600 | 15 |
| +1600 → 3200 | 7.5 |
| +1600 → 4800 | 3.75 |
| +1600 → 6400 | 1.875 |
| 8000 | 0.9375 |

cont'

| time | mass |
|---|---|
| 9600 | 0.46875 |
| 11 200 | 0.234375 g |

ANS

13. Check off the appropriate boxes:

| Statement | Type of Radiation: α | β | γ | x |
|---|---|---|---|---|
| It is the most penetrating type of radiation. | | | ✓ | |
| It travels at the speed of light. | | | ✓ | ✓ |
| It is not produced by radioactive elements. | | | | ✓ |
| It consists of particles. | ✓ | ✓ | | |
| It is not deflected by a magnetic field. | | | ✓ | ✓ |
| It consists of electrons. | | ✓ | | |
| It consists of helium nuclei. | ✓ | | | |
| It can be stopped by a piece of wood. | ✓ | ✓ | | |

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14. Given the following equation of a nuclear disintegration:

mass # 230 $^{230}_{90}Th$ ? $\longrightarrow$ $^{226}_{88}Ra$ + $^{4}_{2}He$

a) What type of radiation is emitted during this decay process?

alpha OR $\alpha$

b) Name the unknown element. Explain how you got your answer.

Unknown element: Th

Explanation: 88 + 2 = 90 = Thorium

c) What is the mass number of this element? Explain your answer, based on the principle of conservation of mass.

Mass number: 230

Explanation: 226 + 4 = 230

15. The equation for the nuclear disintegration of bismuth-214 is the following:

$^{214}_{83}Bi \longrightarrow {}^{214}_{84}Po + ? \; {}^{0}_{-1}e$ (by)

a) What type of radiation is emitted during this decay process?

Beta, OR $\beta$ OR $^{0}_{-1}e$

b) Using the principle of conservation of mass, explain why the mass number remains unchanged.

$^{0}_{-1}e$ = negligible mass lost

∴ mass reactant = mass product

c) Explain why the atomic number increases from 83 to 84.

1 neutron converts into 1 proton

16. Indicate whether each of the following statements regarding the CANDU nuclear power reactor is true (T) or false (F).

a) The same substance serves as a coolant and a moderator. T (heavy water)

b) Cadmium control rods speed up the neutrons. F

c) $D_2O$ Coolant is converted into steam, and then it drives the turbine. F

d) The reactor does not need to be shut down when fuel bundles are changed. T

e) When electricity demand increases, the fission rate in the reactor can be increased to meet this demand. F

f) The coolant circulates in an open system. F (it's in a closed sys)

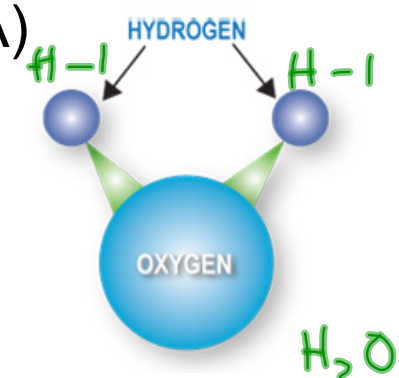
g) Cooling water is pumped into the condenser from a source outside the power station. T

h) Only one uranium isotope undergoes fission in the reactor core. T (U-235)

i) The waste from the nuclear power station is not radioactive since fission reactions have stopped. F

17. Differentiate between the two molecules below. For each, give one location where each is found in the CANDU nuclear power reactor.

A)

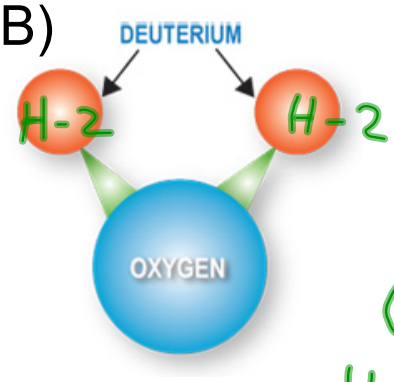



$H_2O$

Common name: regular water

Location found: Boiler

B)




($D_2O$)

Common name: Heavy water

Location found: Coolant/ Reactor core

18. Much research is being conducted in efforts to develop a nuclear power plant that uses fusion instead of fission as the energy source.

a) List two advantages of using fusion rather than fission as an energy source.

① Produces much more energy.
② Produces much less radioactive waste.
③ Fuel for fusion (deuterium) is abundant in seawater.

b) List two problems associated with using fusion as the energy source in a nuclear power plant.

① Requires extremely high temperature
② and pressure.

19. **Canada was the world's largest uranium producer for many years, accounting for about 22% of world output, but in 2009 was overtaken by Kazakhstan. Production comes mainly from the McArthur River mine in northern Saskatchewan province, which is the largest in the world. Production is expected to increase significantly from 2013 as the new Cigar Lake mine comes into operation. With known uranium resources of 572,000 tonnes,as well as continuing exploration, Canada will have a significant role in meeting future world demand.**

a) List three ways that people living near a uranium mine can be exposed to radiation.

- Radon gas
- water contamination
- radioactive dust particles

b) From an economic viewpoint, explain why Canada would continue to invest in uranium mining despite the health risks to Canadians.

Provides jobs and money to Canadians!

20. A huge disadvantage of nuclear power plants is the problem of disposing of nuclear left-over waste.
There are about 270,000 tonnes of used fuel in storage, much of it at reactor sites. About 90% of this is in storage ponds, the balance in dry storage.

Explain why nuclear waste storage is a risk to the environment.

It stays radioactive for billions of years. (remember half-lives!)

21. In spite of the fact that nuclear energy results in radioactive waste production, why is it said that "nuclear energy is a clean source of energy"?

It doesn't produce chemical waste (like greenhouse gases & acid rain)

22. *It doesn't take an accident* for a nuclear power plant to release radioactivity into our air, water and soil. All it takes is the plant's everyday routine operation, and federal regulations permit these radioactive releases.

* Name one possible health effect that radioactive gas leakage may have on people living near the power station.

↑ risk of cancer

23. Accidents involving nuclear reactors such as Chernobyl (1986) have released strontium into the atmosphere, which ultimately settles to the earth's surface as fallout. Chernobyl contributed the largest worldwide burden of strontium-90 contamination, and a substantial portion of the strontium-90 released was deposited in the former Soviet Republics; with the rest being dispersed as fallout worldwide.

After settling into the earth, Sr-90 enters the food chain. It is present in the grass, in the bodies of animals that eat grass, and subsequently in the bodies of people who drink milk from infected cows, or who eat the meat of infected animals. What two kinds of cancer can be caused by the build-up of this harmful radioactive isotope in the body?

Blood cancer (leukemia) + bone cancer (Sarcoma)

24. Radioactive isotopes like fluorine-18 (half life of 20 minutes) are used in medicine (specifically for PET scans). Give one reason that it is important that radioisotopes have a short half life.

So they leave the body quickly

25. In the space beside each statement below, place an "A" for atomic bomb or an "H" for hydrogen bomb.

H a) This bomb is a thermonuclear bomb.

A b) In this bomb, the fissile material is divided into two separate blocks, each with a mass lower than the critical mass.

H c) This bomb involves nuclear fusion.

H d) In theory, there is no limit to the explosive power of this bomb.

A e) Plutonium can be used for this type of bomb.

A f) This bomb produces less energy than the other type of bomb.

H g) The other type of bomb is required to detonate this bomb.

A h) A limited amount of material must be used to make this bomb.

26. The following statements pertain to one or more of the types of power stations that were covered in class.
For each statement, write the corresponding letter in each of the boxes to which it applies.
Each letter may need to be placed in more than one of the boxes!

A) This type of power station has a coolant. $D_2O$

B) Coal may be used as the fuel source in this type of power station.

C) This type of power station has a condenser.

D) This type of power station has a boiler.

E) This type of power station produces waste or pollution.

F) Pressurized steam drives the turbine in this type of power station.

G) This type of power station uses the potential gravitational energy of water.

| Hydroelectric Power Station | Conventional Thermal Power Station | Nuclear Power Station |
|---|---|---|
| G | B, C, D, E, F | A, C, D, E, F |

27. Canada, Russia, and the United States vary in terms of the components used in their nuclear power plants.

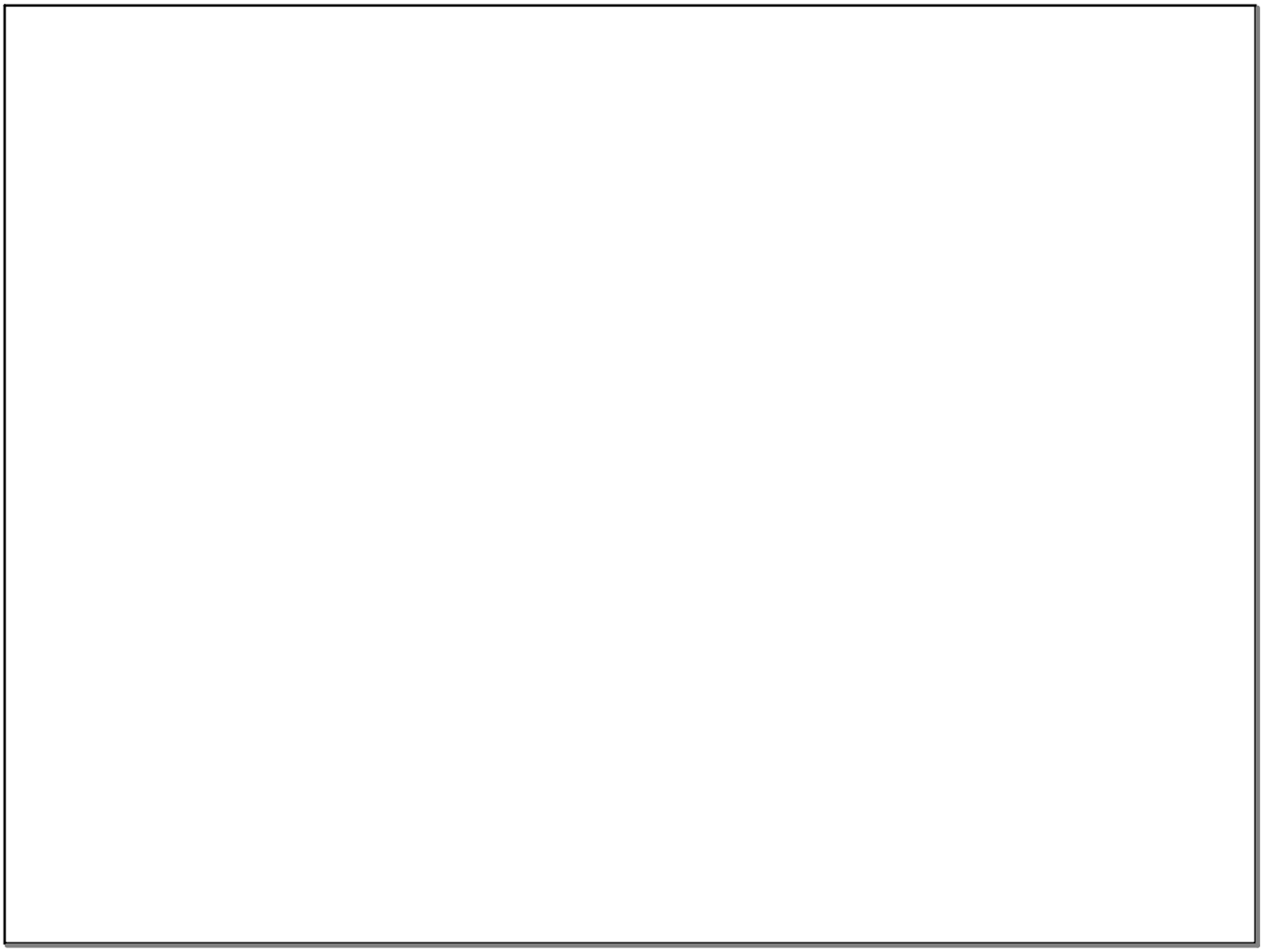
Choose the correct answer from the list below and write it in the appropriate box.

| | Reactor Components | Canada | Russia | United States |
|---|---|---|---|---|
| Plutonium, Natural Uranium, or Enriched Uranium | Type of Fuel | Natural Uranium | Enriched Uranium | Enriched Uranium |
| Heavy Water, Ordinary Water, or Graphite | Moderator | heavy water | Graphite | ordinary water |
| Heavy Water, Ordinary Water, or Pressurized Gas | Coolant | heavy water | Ordinary water | ordinary water |
| | | | | |

28. List two ways in which irradiation prevents a potato from spoiling quickly.

① Prevents potatoes from sprouting eyes.

② Kills bacteria.



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